

5.2 Bay-Delta Hydrodynamics and Riverine Hydraulics

5.2.1 SUMMARY

Delta hydrodynamic conditions are primarily determined by tides, Delta inflow and outflow, diversions, and Delta channel configuration. The CALFED Bay-Delta Program (Program) alternatives could result in changes to Delta inflow and export patterns, and modifications to the configuration of Delta channels. These changes would affect Bay-Delta hydrodynamics and riverine hydraulics, and could result in impacts or benefits to other environmental resources dependent on Delta flow patterns.

Although Program-induced changes in hydraulic parameters, including flow, velocity, stage, and related variables, such as X2 position, are described in this section, the environmental implications of these changes are not. Environmental implications of changes in Bay-Delta hydrodynamics and riverine hydraulics are addressed in other sections of this report in the context of each of the resources affected by the changes.

Preferred Program Alternative. The Preferred Program Alternative could affect Bay-Delta hydrodynamics and riverine hydraulics through changes in the configuration of Delta channels, construction of new storage facilities, and related changes in system operations. Construction of a Hood facility could significantly affect Bay-Delta hydrodynamics. With a Hood diversion of 4,000 cfs, net flow in the San Joaquin River west of the Mokelumne River is more frequently positive. Similar to the No Action Alternative, under the Preferred Program Alternative without a Hood diversion, net flow in the San Joaquin River is generally negative toward the pumping plants in the south Delta from the junction of the Sacramento and San Joaquin Rivers. This condition is most pronounced at times of high exports and low Delta inflow.

Under the Preferred Program Alternative, new storage facilities may be constructed in the Sacramento River and San Joaquin River Regions and in the south-of-Delta SWP and CVP Service Areas. Storage of water takes place during high-flow periods; release of water generally takes place during lower-flow periods. Resulting changes in Delta inflow and diversion patterns would cause relatively small effects on Delta channel flows when compared to Delta inflows, diversions, and tidal actions.

The Program alternatives could result in changes to Delta inflow and export patterns, and modifications to the configuration of Delta channels. These changes would affect Bay-Delta hydrodynamics and riverine hydraulics, and could result in impacts or benefits to other environmental resources dependent on Delta flow patterns.

The Preferred Program Alternative could affect Bay-Delta hydrodynamics and riverine hydraulics through changes in the configuration of Delta channels, construction of new storage facilities, and related changes in system operations.



Alternatives 1, 2, and 3. During most months under Alternative 1, the direction of net flows in the San Joaquin River is negative toward the pumping plants from the junction of the Sacramento and San Joaquin Rivers. This condition is most pronounced at times of high exports and low Delta inflow. Under Alternative 2, sufficient quantities of water are diverted at Hood to maintain net positive flow in the San Joaquin River west of the Mokelumne River. Under Alternative 3, about 40-90% of the water exported from the Delta would pass through an isolated conveyance facility and about 10-60% would be diverted directly from the south Delta—depending on the operating rules and capacity of the isolated conveyance facility. For most Delta channels, net positive flow occurs under Alternative 3. The effects on Bay-Delta hydrodynamics and riverine hydraulics from potential new storage facilities under Alternatives 1, 2, and 3 are similar to those described for the Preferred Program Alternative.

5.2.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that are currently unknown or reflect differing opinions among technical experts. Unknown information includes data that are not available and cannot readily be obtained. The opinions of technical experts can differ, depending on which assumptions or methodology they use.

Evaluation of Bay-Delta hydrodynamics and riverine hydraulics relies on the development of assumptions and methodologies that may result in disagreements among technical experts and, therefore, constitute areas of controversy as defined by CEQA. The use of different assumptions and methodologies may lead to conclusions that overestimate or underestimate the impact of Program actions on Bay-Delta hydrodynamics and riverine hydraulics. To fully describe potential consequences of Program actions, a reasonable range of uncertainty has been incorporated into this programmatic analysis. For details, refer to Section 5.1.4.2, "Addressing Uncertainty," in Section 5.1, "Water Supply and Water Management."

The Program recognizes the importance of Bay-Delta hydrodynamics and riverine hydraulics to regions potentially affected by Program actions. One important area of controversy centers on the magnitude of effects of Program actions on Delta hydrodynamics and the subsequent effect on access to water supplies for Delta agriculture. As a multi-million dollar industry, agriculture is the basis of livelihood for many small communities in the Delta. Another important area of controversy centers on the potential impacts of riverine flow modification on ecosystem health. Regardless of disagreements over the measurement of Program effects, CALFED recognizes the importance of adequate access to water supplies and flows to Delta agriculture and ecosystems. At the programmatic level of analysis, any potential adverse effect on flows or water levels that affect individuals or businesses dependent on Delta diversions for their livelihood is considered a potentially significant effect. Likewise, any potential adverse effects on riverine flow patterns that affect ecosystem health is considered a potentially significant impact. Subsequent project-specific environmental analysis will evaluate these impacts in more detail.

One important area of controversy centers on the magnitude of effects of Program actions on Delta hydrodynamics and the subsequent effect on access to water supplies for Delta agriculture.



5.2.3 AFFECTED ENVIRONMENT/ EXISTING CONDITIONS

This section describes existing conditions for Bay-Delta hydrodynamics and riverine hydraulics. As discussed further in Section 5.2.4, existing Bay-Delta hydrodynamics and riverine hydraulics were assessed through simulation of 1995-level conditions. A comparison of existing conditions with the 2020-level No Action Alternative is provided in Section 5.2.6.

5.2.3.1 DELTA REGION

Delta hydraulics and hydrodynamics are influenced by the interaction of tributary inflows, tides, Delta geometry, and diversions. The Delta receives runoff from a watershed that includes more than 40% of the state's land area. Tributaries that directly discharge into the Delta include the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras Rivers.

Existing conditions in the Delta are the result of the many changes that have occurred as the Delta Region has developed over the past 150 years. During the mid-1800s, the Delta, an area of nearly 750,000 acres, was mostly undeveloped tidal marsh. The Delta was inundated each year by winter and spring runoff. During this early period prior to development, Delta channel geometry changed in response to the forces of floods and tides. By 1930, nearly all Delta marshland had been reclaimed for agriculture, peat production, and urban and industrial uses. Delta channels and islands became more permanently established. New linear channels were dredged, replacing natural meandering channels. These new channels were constructed for navigation, to improve circulation, and to provide the material needed for levee construction. Examples of new channels include Grant Line Canal, Victoria Canal, Empire Cut, Columbia Cut, and the Delta Cross Channel (DCC). The two major navigation waterways include the Stockton Deep Water Channel, completed in 1933 (along the San Joaquin River), and the Sacramento Deep Water Channel, completed in 1963.

During the early period prior to development, Delta channel geometry changed in response to the forces of floods and tides.

Today, the Delta consists of about 740,000 acres, including approximately 500,000 acres of rich farmland, interlaced with hundreds of miles of waterways that divide the Delta into islands. Some of the island interiors are as much as 25 feet below sea level. Therefore, the Delta relies on about 1,100 miles of levees for flood protection. Refer to Figure 5.2-1 for a Delta location map.

Water exports from the Delta began in 1940, following completion of the Contra Costa Canal, a unit of the CVP. In 1951, the Tracy Pumping Plant began supplying water to the Delta-Mendota Canal (DMC). The SWP began exporting water through the South Bay Aqueduct (SBA) in 1962 (through an interim connection to the CVP's DMC). As statewide water demands grew, the SWP began pumping from the south Delta in 1967



(supplying the California Aqueduct) and from the north Delta in 1987 (supplying the North Bay Aqueduct [NBA]).

To facilitate movement of Sacramento River water to pumping facilities in the south Delta, Reclamation completed the DCC in 1951. This channel connects the Sacramento River to Snodgrass Slough and the Mokelumne River system. The flow from the Sacramento River is controlled by two 60-foot gates on the Sacramento River near Walnut Grove. Downstream from the DCC, Georgiana Slough also connects the Sacramento River to the Mokelumne River system, allowing Sacramento River water to enter the central Delta.

Delta hydrodynamic conditions primarily are determined by inflow to the Delta from tributary streams, daily tidal inflow and outflow through the Bay, and pumping from the south Delta through the Harvey O. Banks Delta Pumping Plant (Banks Pumping Plant) and Tracy Pumping Plant. Since tidal inflows are about equal to tidal outflows during each daily tidal cycle, tributary inflows and export pumping are the principal variables that define the range of hydrodynamic conditions in the Delta.

Twice-daily tides move water from San Francisco Bay into the Delta. The average incoming and outgoing Delta tidal flow is about 170,000 cfs at Chipps Island. By comparison, the current allowable SWP and CVP combined export capacity is about 11,000 cfs. Historically, during extremely low runoff periods in summer, salt from tidal flows intruded into the Delta as far as Hood. During winter and spring, fresh water from heavy rains pushed the salt water back, well into the Bay, and sometimes beyond. Salt-water intrusion into the Delta during summer is controlled by tides, fresh-water inflows from reservoir releases, and Delta pumping. Reservoir storage and releases have resulted in increased summer and fall flows, and dampened peak winter and spring flows. In very wet years, reservoirs are unable to control runoff, and salinity in the Bay is nearly reduced to fresh-water levels.

The three major sources of fresh water to the Delta are the Sacramento River, the San Joaquin River, and east side streams. The Sacramento River (including the Yolo Bypass) contributes about 77-85% of the fresh-water inflows to the Delta. The San Joaquin River contributes roughly 10-15%. Streams on the east side, including the Mokelumne River, provide the remainder of the Delta inflow. On average, about 10% of the Delta inflow is withdrawn for local use, 30% is withdrawn for export by the CVP and SWP, 20% is required for salinity control, and the remaining 40% provides outflow to the San Francisco Bay ecosystem in excess of minimum identified requirements. These unallocated outflows are negligible during most dry seasons.

Each region in the Delta is dominated by different hydraulic variables during any given period of time. In the west Delta, for example, tidal influences are strong and reverse flows occur frequently. The north Delta is more dominated by Sacramento River and Mokelumne River inflows. The south Delta is more affected by both San Joaquin River inflows and export pumping. All of these influences intersect in the central Delta.

Twice-daily tides move water from San Francisco Bay into the Delta. The average incoming and outgoing Delta tidal flow is about 170,000 cfs at Chipps Island. By comparison, the current allowable SWP and CVP combined export capacity is about 11,000 cfs.

The three major sources of fresh water to the Delta are the Sacramento River, the San Joaquin River, and east side streams.

Each region in the Delta is dominated by different hydraulic variables during any given period of time.



QWEST is a measure of net flow in the lower San Joaquin River and other smaller Delta channels. In this evaluation, QWEST is estimated as a function of cross-Delta flow, San Joaquin River and eastside tributary inflow to the Delta, in-Delta diversions, and exports from the Delta. Over the long-term period under existing conditions, the greatest average monthly positive QWEST flow typically occurs in February and is about 7,300 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and is about -3,600 cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under existing conditions, the greatest average monthly positive QWEST flow typically occurs in April and is about 1,300 cfs. The greatest average monthly reverse flow typically occurs in December and is about -5,000 cfs.

Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports.

Water levels, or stage, vary greatly during each tidal cycle, from less than 1 foot on the San Joaquin River near Interstate 5 to more than 5 feet near Pittsburg. In the south Delta, lowering water levels associated with CVP and SWP pumping are of concern for local agricultural diverters. Over the long-term period under existing conditions, the highest minimum stage in Middle River typically occurs in February and is about 0.1 foot below mean sea level (msl). The lowest minimum stage typically occurs in August and is about 0.8 foot below msl. During dry and critical years under existing conditions, the highest minimum stage in Middle River typically occurs in April and is about 0.6 foot below msl. The lowest minimum stage typically occurs in September and is about 0.7 foot below msl.

5.2.3.2 BAY REGION

The San Francisco Bay system includes the Suisun, San Pablo, and South Bays. The outlet of San Francisco Bay at Golden Gate Bridge is located 74 km from Chipps Island, the interface between the Delta and Suisun Bay. North of Suisun Bay and east of Carquinez Strait lies the Suisun Marsh, an extensive mosaic of variably controlled tidal marshlands. Tributaries to San Pablo Bay include the Napa, Sonoma, and Petaluma Rivers. The principal tributary to the South Bay is Coyote Creek. Numerous lesser streams collectively drain the Bay Region.

The San Francisco Bay system includes the Suisun, San Pablo, and South Bays.

San Francisco Bay currently has a surface area of about 400 square miles at mean tide level. Most of the Bay's shoreline has a mild slope, which creates a relatively large intertidal zone. The volume of water in the Bay changes by about 21% from mean higher-high tide to mean lower-low tide. The overall average depth of the Bay is only about 20 feet, with the Central Bay averaging 43 feet and the South Bay averaging 15 feet. San Francisco Bay is surrounded by about 130 square miles of tidal flats and marshes.

Average net Delta outflow into the Bay Region as measured at Chipps Island is about 20,400 cfs, or about 15 MAF per year. Average natural fresh-water inflow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. During summer months of critically dry years, net Delta outflow can fall as low as 3,000 cfs.



In addition to Delta outflow, San Francisco Bay receives fresh-water inflow from the Napa, Petaluma, and Guadalupe Rivers and from Alameda, Coyote, Walnut, and Sonoma Creeks and a number of smaller streams. The total average inflow of these tributaries (excluding the Delta) is about 350 TAF. Stream flow is highly seasonal, with more than 90% of the annual runoff occurring during November through April.

Suisun Bay and the adjacent 80,000-acre Suisun Marsh are located near the downstream end of the Delta. Suisun Bay is the area where the effects of mixing fresh water and salt water are typically most pronounced.

Downstream of Carquinez Strait are the San Pablo and central San Francisco Bays. Carquinez Strait separates these bays from Suisun Bay and the Delta, and allows tides to play a leading role in their salinity and circulation. These embayments can become quite fresh, especially at the surface, during extremely high fresh-water flows. During these high flows, the entrapment zone can be temporarily relocated downstream to San Pablo Bay. During periods of low fresh-water flows and high tides, these embayments are quite saline.

The South Bay is different from the other parts of the system. This area is not in the main path of Delta outflows. Thus, except during sustained high-outflow periods, water quality is not significantly affected by Delta outflow. These sustained events do, however, play a significant role in flushing contaminants such as copper and nickel from the South Bay. During low Delta outflow periods, evaporation, combined with limited tidal flushing, can cause salinity levels to be higher in the South Bay than in the ocean outside the Golden Gate. Large level tracts of the South Bay are still used as evaporation ponds for salt production.

The Bay Region receives unallocated and minimum required outflows from the Delta Region. These can range from the minimum required flow of less than 4 to nearly 60 MAF, depending on precipitation and diversions. This water is used in the Bay Region primarily for ecological and water quality maintenance purposes.

The location of the mixing zone between fresh water from the Delta and saline water from the Bay varies with the amount of Delta outflow, as well as tides. The mixing zone is pushed downstream during periods of high Delta outflow and can move upstream into the Delta if Delta outflow is low or during spring neap tides. In order to track and regulate this movement, a standard has been developed, called X2, which represents the mean distance in kilometers (km) from the Golden Gate Bridge, where the salinity concentration is 2 parts per thousand (ppt) and the electrical conductivity (EC) is 2,640 μ mhos/cm. The X2 position approximates the location of the entrapment zone, an area of high biological productivity. The Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta defines requirements for maintaining X2 at Port Chicago and Chipps Island. The CVPIA provides water supplies to further enhance X2 position for environmental benefits.

Suisun Bay is the area where the effects of mixing fresh water and salt water are typically most pronounced.

During low Delta outflow periods, evaporation, combined with limited tidal flushing, can cause salinity levels to be higher in the South Bay than in the ocean outside the Golden Gate. Large level tracts of the South Bay are still used as evaporation ponds for salt production.

The mixing zone is pushed downstream during periods of high Delta outflow and can move upstream into the Delta if Delta outflow is low or during spring neap tides.



5.2.3.3 SACRAMENTO RIVER REGION

The Sacramento River Region contains the entire drainage area of the Sacramento River and its tributaries, and extends almost 300 miles from Collinsville in the Delta north to the Oregon border. The total land area within the region is 26,960 square miles. Average annual precipitation is 36 inches, and average annual runoff is approximately 22.4 MAF.

The Sacramento River enters the Delta at Freeport. The drainage area of the Sacramento River above Sacramento, 11 miles north of Freeport, is 23,502 square miles. The average annual flow of the Sacramento River at Freeport is 16 MAF, more than twice the average annual flow measured in the Sacramento River above the confluence with the Feather River. The maximum mean monthly discharge at Freeport measured for the period of record was 71,340 cfs; the minimum mean monthly discharge was 4,494 cfs. Most flood flows that come from the upper Sacramento River, Feather River, and Sutter Bypass are diverted west of Freeport and the Sacramento area into the Yolo Bypass through the Fremont Weir at Verona. Overflows occur at this point when Sacramento River flows exceed 55,000 cfs at Verona. Sacramento River overflows also may enter the Yolo Bypass just north of Sacramento through the Sacramento Weir.

The two major tributaries to the Sacramento River along its lower reach are the Feather River (which also includes flows from the Yuba River) and the American River. The combined flows of the Feather River and the Sutter Bypass enter the river near Verona. The American River joins the Sacramento River north of downtown Sacramento. Smaller contributions are made by the Natomas Cross Canal, draining the area between the Bear River and American River, and the Colusa Basin Drain, which drains the west side of the Sacramento Valley from about Willows south to Knights Landing.

Nine locations were selected as the focal points for analyzing current hydraulic conditions in the Sacramento River Region (Figure 5.2-1). The locations were selected based on their proximity to principal hydraulic features in the region, and include stations on both the Feather and American Rivers.

The DWRSIM model was used to simulate monthly flows. Flow simulations illustrate how current storage and conveyance facility configurations would respond to the 73-year record of hydrologic input data from water year 1922 through water year 1994. Hydraulic geometry equations were derived from recent USGS gaging station data. These equations were used to estimate the mean velocity, stream width, and mean depth corresponding to the simulated average monthly discharges at each study location.

The results of the flow simulations for existing conditions for February and September are presented in Table 5.2-1. The maximum, minimum, and average values of hydraulic parameters for February and September are shown in the table. February was selected to represent wet season flows because average flows are highest in that month. September represents dry season flows because average flows are lowest during that month.

The Sacramento River Region contains the entire drainage area of the Sacramento River and its tributaries, and extends almost 300 miles from Collinsville in the Delta north to the Oregon border.

The two major tributaries to the Sacramento River along its lower reach are the Feather River (which also includes flows from the Yuba River) and the American River.

The DWRSIM model was used to simulate monthly flows. Flow simulations illustrate how current storage and conveyance facility configurations would respond to the 73-year record of hydrologic input data from water year 1922 through water year 1994.

Stream velocities at any point are greater in the center of the channel and lower at the margins and near the channel bottom due to friction.



Table 5.2-1. Range of Existing Hydraulic Conditions at Selected Stations in the Sacramento River Region for February and September

FLOW CONDITION BASED ON 73-YEAR HYDROLOGICAL RECORD	SACRAMENTO RIVER AT				AMERICAN RIVER AT FAIR OAKS	FEATHER RIVER AT GRIDLEY
	FREEPORT	VERONA	WILKIN SLOUGH	KESWICK		
February						
Discharge (cfs)						
Maximum	90,878	95,756	95,758	41,772	30,098	26,992
Minimum	10,569	4,472	4,472	2,943	455	813
Average	34,554	22,411	22,411	9,535	4,470	5,987
Mean velocity (fps)						
Maximum	4.3	4.4	5.6	6.2	5.8	4.4
Minimum	1.3	1.7	2.3	0.7	0.7	0.3
Average	2.5	2.9	3.7	2.3	2.2	1.8
Top width (feet)						
Maximum	651.3	799.4	367.0	612.5	456.6	318.4
Minimum	584.9	464.2	217.3	423.0	256.1	273.8
Average	620.5	530.6	286.3	505.2	351.0	298.5
Mean depth (feet)						
Maximum	34.5	29.1	46.6	9.7	11.8	17.2
Minimum	15.2	5.6	8.9	3.8	2.6	9.4
Average	23.9	14.4	21.2	5.5	6.0	10.9
September						
Discharge (cfs)						
Maximum	22,439	9,870	9,870	8,553	5,089	6,228
Minimum	7,545	3,382	3,382	4,358	309	732
Average	12,141	5,463	5,463	5,946	2,745	1,718
Mean velocity (fps)						
Maximum	2.0	2.2	2.9	2.4	2.3	1.8
Minimum	1.1	1.6	2.1	0.6	0.5	0.3
Average	1.4	1.8	2.5	1.8	1.7	0.6
Top width (feet)						
Maximum	607.3	495.7	248.8	582.0	357.3	298.9
Minimum	575.1	453.5	207.1	571.3	242.8	272.6
Average	588.9	471.9	224.9	576.2	328.2	282.8
Mean depth (feet)						
Maximum	20.3	8.9	13.6	8.2	6.2	11.0
Minimum	13.4	4.7	7.6	7.4	2.3	9.3
Average	16.0	6.3	9.9	7.7	5.0	9.6

Notes:

cfs = Cubic feet per second.
fps = Feet per second.

The values shown in the table are estimates for comparison purposes. They depend on local stream channel geometry at the measurement points. Average velocities are calculated from the average monthly discharge divided by the cross-sectional area of the stream channel. Stream velocities at any point are greater in the center of the channel and lower at the margins and near the channel bottom due to friction. In addition, flow conditions may vary considerably over a month, particularly during the wet season.

Figure 5.2-2 shows the distribution of the simulated average monthly flows at Freeport using the 73-year hydrologic record. The Freeport station is used to represent the point at which the Sacramento River enters the Delta. The heights of the bars correspond to the rate of discharge that is exceeded with the frequency shown in the table below. The exceedance frequencies are based on the percentile ranking of the discharge values for the

The Freeport station is used to represent the point at which the Sacramento River enters the Delta.



Figure 5.2-2. Sacramento River Flow Frequency at Freeport under Existing Conditions

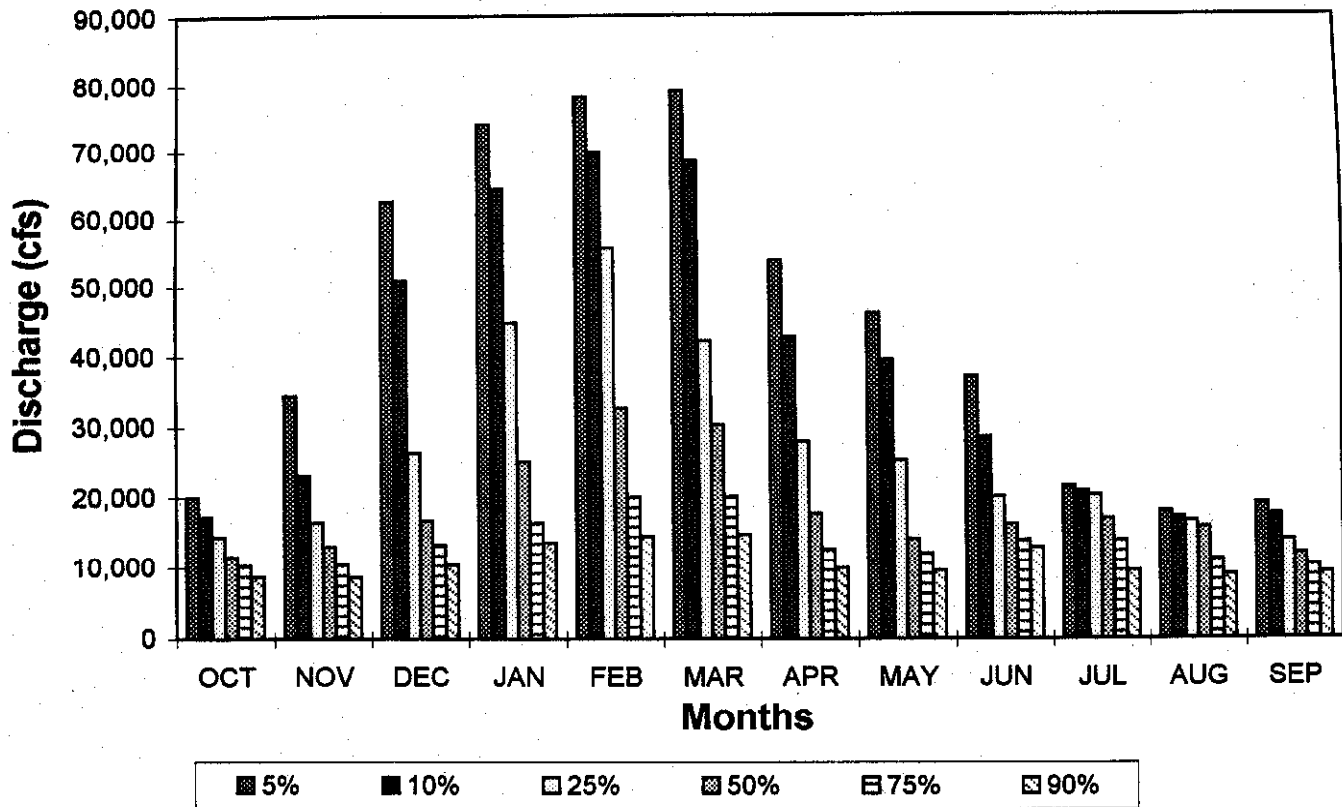
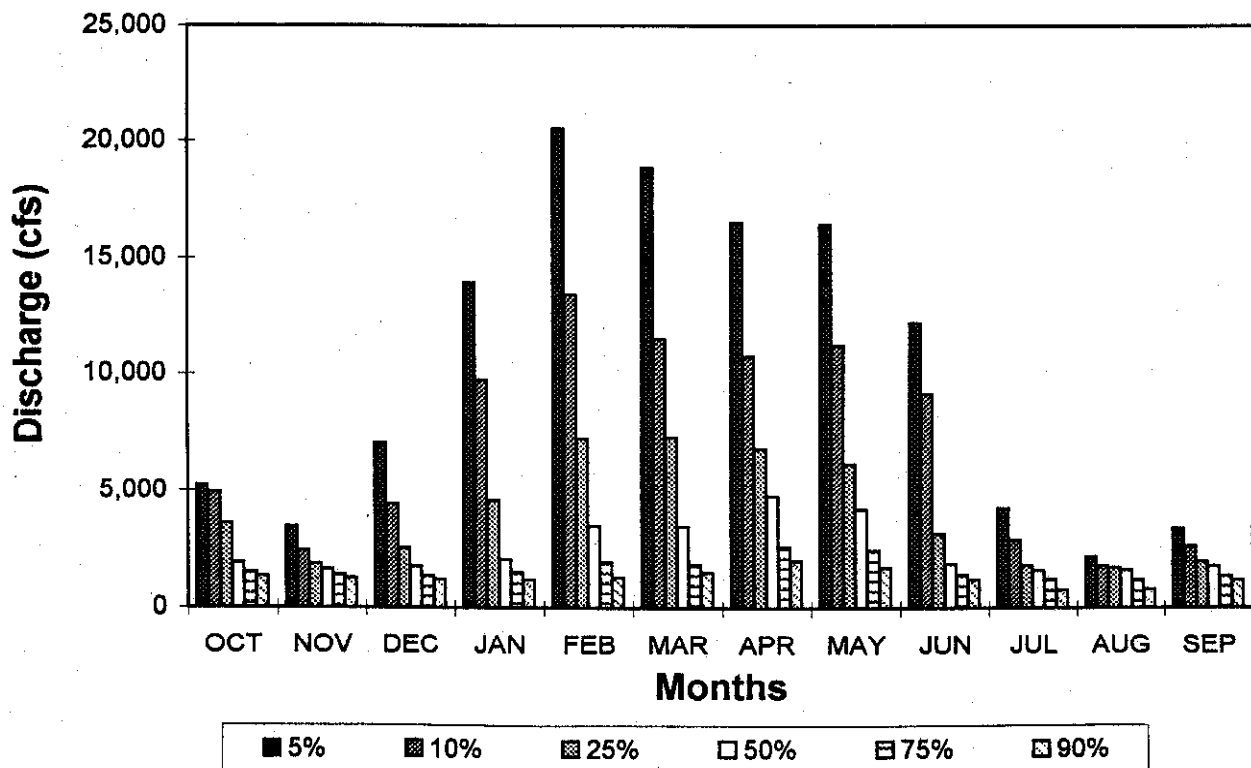


Figure 5.2-3. San Joaquin River Flow Frequency at Vernalis under Existing Conditions



month. The percentile is calculated by ranking the values from smallest to largest. Since DWRSIM calculates the average monthly discharge for each month of the 73-year simulation period, 73 discharge values are associated with each month.

The maximum simulated discharge at Freeport in February is 91,000 cfs, the minimum is 10,600 cfs, and the average is 35,000 cfs. Figure 5.2-2 provides more information about the distribution of values between the extremes. Under the column representing February, the first value corresponds to the highest bar in the chart above it and is 80,000 cfs. This discharge would be exceeded in 5 out of 100 years in February at Freeport; therefore, this discharge has a 5% probability of being exceeded.

5.2.3.4 SAN JOAQUIN RIVER REGION

The San Joaquin River Region includes the Central Valley south of the watershed of the American River. It is generally drier than the Sacramento Valley, and flows into the Delta from the San Joaquin River are considerably lower than those from the Sacramento River. The region is also subject to extreme variations in flow, as exemplified by flooding that occurred during January 1997.

The drainage area of the San Joaquin River above Vernalis, the point at which the river enters the Delta, is 13,356 square miles, including 2,100 square miles of drainage contributed by James Bypass. Inflows from the Merced, Tuolumne, and Stanislaus Rivers historically contribute more than 60% of the flows in the San Joaquin River at Vernalis. Vernalis lies just inside the boundary of the Delta, but it is widely used as a monitoring point for Delta inflows and standards.

The USGS has operated a gaging station on the San Joaquin River near Vernalis since 1922, although complete records are available only back to 1930. The instantaneous maximum flow recorded at the station was 79,000 cfs, observed on December 9, 1950. The instantaneous minimum flow was 19 cfs, recorded on August 10, 1961. The maximum mean monthly discharge was 40,040 cfs in March 1983, and the minimum mean monthly discharge was 93 cfs in July 1977.

Three locations were selected to represent the range of existing hydraulic conditions in the San Joaquin River Region. The most important of these is the San Joaquin River at Vernalis because of its location near the Delta. The San Joaquin River at Newman was chosen to characterize the upstream portion of the river. The Stanislaus River below Goodwin Dam also was selected.

Table 5.2-2 presents the estimated range in discharge, average stream velocities, top width, and mean depth for February (high-flow period) and August (low-flow period). Figure 5.2-3 shows the frequency distribution of flows for the San Joaquin River at Vernalis, the point at which the river flows into the Delta. The data are plotted at the

The San Joaquin River Region includes the Central Valley south of the watershed of the American River. It is generally drier than the Sacramento Valley, and flows into the Delta from the San Joaquin River are considerably lower than those from the Sacramento River.

Three locations were selected to represent the range of existing hydraulic conditions in the San Joaquin River Region. The most important of these is the San Joaquin River at Vernalis because of its location near the Delta.



Table 5.2-2. Range of Existing Hydraulic Conditions at Selected Stations in the San Joaquin River Region for February and August

FLOW CONDITION BASED ON 73-YEAR HYDROLOGICAL RECORD	SAN JOAQUIN RIVER AT		STANISLAUS RIVER BELOW GOODWIN DAM
	VERNALIS	NEWMAN	
February			
Discharge (cfs)			
Maximum	33,024	19,447	4,390
Minimum	911	309	211
Average	5,539	2,541	537
Mean velocity (fps)			
Maximum	3.1	3.5	4.1
Minimum	1.4	0.9	1.1
Average	2.1	1.8	1.7
Top width (feet)			
Maximum	503.7	498.7	146.7
Minimum	245.5	139.7	87.3
Average	289.9	190.7	100.1
Mean depth (feet)			
Maximum	19.5	10.7	7.3
Minimum	19.5	2.4	2.2
Average	19.5	7.8	3.1
August			
Discharge (cfs)			
Maximum	3,073	683	2,423
Minimum	618	341	114
Average	1,510	520	855
Mean velocity (fps)			
Maximum	1.8	1.2	3.4
Minimum	1.3	0.9	0.8
Average	1.6	1.1	2.2
Top width (feet)			
Maximum	274.6	157.1	130.3
Minimum	236.9	141.8	79.7
Average	257.2	150.9	107.2
Mean depth (feet)			
Maximum	5.9	3.8	5.5
Minimum	19.5	2.6	1.7
Average	19.5	3.3	3.7

Notes:

cfs = Cubic feet per second.
fps = Feet per second.

same scale used to plot the data for Sacramento River stations in order to illustrate the relative contributions in flows to the Delta from each river. As described for Sacramento River stations, the results indicate that the average winter flows are skewed by infrequent elevated flows. The medians in the low-flow months of July through November are nearly the same and stay within a narrow range, reflecting the effects of reservoir operations during these months.



5.2.3.5 OTHER SWP AND CVP SERVICE AREAS

Surface water flows in the other SWP and CVP service areas are not directly affected by the Program. Therefore, the region is not discussed further in Section 5.2.

Surface water flows in the other SWP and CVP service areas are not directly affected by the Program.

5.2.4 ASSESSMENT METHODS

5.2.4.1 TOOLS

Refer to Section 5.1.4.1 for a description of tools used to assess potential impacts on Bay-Delta hydrodynamics and riverine hydraulics.

5.2.4.2 MODELING ASSUMPTIONS

Refer to Section 5.1.4.3 and Attachment A for a description of modeling assumptions used to assess potential impacts on Bay-Delta hydrodynamics and riverine hydraulics.

5.2.4.3 APPROACH

Delta hydrodynamic simulations were performed with DSM2 using Delta inflow hydrology resulting from the DWRSIM project operations simulations. Additionally, input to DSM2 was modified to represent different Delta geometries and export diversion locations. Flow patterns, velocities, water levels and transport processes within the Delta were evaluated reflecting the differences in input hydrology and Delta configuration. The DSM2 simulation output captures the effects of an average tide on Delta flows and water quality and also tracks the pattern of water migration from preselected points throughout the Delta (often referred to as "particle" or "mass fate" tracking).

The DSM2 simulations incorporate a 16-year hydrologic period from October 1976 to September 1991. Where modeling results were incomplete or not applicable, impacts were estimated based on other available information and professional judgment. Other methods of analysis are documented as needed in this document.

Delta hydrodynamic simulations were performed with DSM2 using Delta inflow hydrology resulting from the DWRSIM project operations simulations. The DSM2 simulation output captures the effects of an average tide on Delta flows and water quality and also tracks the pattern of water migration from preselected points throughout the Delta.

DSM2 Modeling

Potential Delta impacts evaluated with DSM2 include the following:

- Effects on monthly average net flows, tidal velocities, and stages in Delta channels.
 - Effects on monthly average Delta flow patterns at several locations in the Delta.
 - Changes in monthly average salinity.
 - Changes in the fate of mass released at particular locations in the Delta.
-



Delta Region

Hydrodynamic impacts of Program alternatives on the Delta were evaluated based on in-Delta modifications and changes in CVP and SWP operations. The potential impacts on the Delta were evaluated with DSM2 as shown in the box.

Several Delta channel flows were evaluated and summarized in this document for each Program alternative, including: Sacramento River flow at Rio Vista, QWEST flow, cross-Delta flow, Old River flow at Bacon Island, and San Joaquin River flow at Antioch. For each Program alternative, Delta channel stage was evaluated and summarized at Old River upstream of Victoria Island and at Middle River at Paradise Cut.

The DSM2 model was used to perform several mass tracking simulations for existing conditions and the Program alternatives, including the No Action Alternative. Mass tracking simulations provide an assessment of particle movement in the Delta under different hydrologic conditions. Mass tracking provides insight into relationships between Delta circulation patterns and the fate, movement, and residence time of fish eggs and larvae. The term “mass injection” is used to indicate the simulation of mass addition to the model for analysis purposes.

Mass Tracking

The transport and fate of mass released into the Delta at various locations was simulated for the following flow conditions:

- High inflow/high pumping, represented by February 1979
 - Medium inflow/low pumping, represented by April 1991
 - Low inflow/high pumping, represented by October 1989
 - Low inflow/low pumping, represented by July 1991
-

These flow conditions were selected to bookend the full range of conditions expected to result from implementing Program alternatives. The months indicated were selected based on combinations of high and low events of inflows and high exports conditions.

Through simulation studies, mass was released at three discrete locations in the Delta to determine its fate under existing conditions and the Program alternatives. Mass was injected in the north Delta at Freeport, in the central Delta at Prisoner's Point, and in the south Delta at Vernalis. Differences between alternatives were evaluated for all three injection points by comparing the change in distribution of mass after 30 days.

The distribution of mass was evaluated by determining the relative percentages of mass reaching predetermined locations. These percentages consist of the amount of mass that stay in the Delta, the amount that is lost to the Delta islands, the amount that is lost to exports, and the amount that reaches Chipps Island. Mass fate assessments were limited to water management Criterion B. Criterion B results in greater potential changes in mass fate relative to existing conditions than Criterion A.

Through simulation studies, mass was released at three discrete locations in the Delta to determine its fate under existing conditions and the Program alternatives.

Bay Region

The evaluation of impacts on Bay Region hydrodynamics that are associated with the Program alternatives focuses on X2 position and Delta outflow. Section 5.2 does not



evaluate the potential changes of flow regimes on sediment transport from the Delta to the Bay and flow-related mixing and transport of sediments within the Bay Region. Sediment movement is a dominant transport mechanism for many contaminants.

Sacramento River and San Joaquin River Regions

DWRSIM model studies provide a preliminary assessment of the magnitude of riverine flow changes that would be expected for each Program alternative and variation. The hydraulic effects of some configurations are expected to be similar to other configurations. Differences between such configurations are discussed in qualitative terms.

The output from DWRSIM consists of calculated monthly flow volumes representing the amount of water in thousands of acre-feet (TAF) that passes a control point defined in the model. These volumes can be readily converted to an average monthly flow rate expressed in cfs. With a few exceptions, the control points generally represent actual locations along channels within the storage and conveyance system. Two locations in the Sacramento River and San Joaquin River Regions (Freeport and Vernalis) were selected as the focal points for analyzing hydraulic changes in the rivers.

DWRSIM model studies also provide a preliminary assessment of releases from existing reservoirs, as well as diversions and releases from new reservoirs. Simulation results of reservoir releases are presented from a regional perspective, consistent with a programmatic-level evaluation. While changes in reservoir release flows were estimated for each of the larger facilities in the Sacramento River and San Joaquin River Regions, results are aggregated for purposes of presentation. Sacramento River Region reservoirs include Shasta, Oroville, and Folsom. San Joaquin River reservoirs include New Melones, New Don Pedro, and McClure. The evaluation of new reservoirs in the Sacramento River Region distinguishes between releases for environmental uses and for water supply uses.

5.2.5 SIGNIFICANCE CRITERIA

Although Program-induced changes in hydraulic parameters, such as flow, velocity, stage, and related variables (for example, X2 position), are described in this section, their significance and the environmental implications of these changes are not discussed. The significance of these changes is addressed in other sections of this report in the context of each of the resources affected by the changes.

5.2.6 NO ACTION ALTERNATIVE

To assess the consequences of the various Program alternatives on Bay-Delta hydrodynamics and riverine hydraulics in the Program study area, a preimplementation condition must be established. Typically, existing conditions provide an adequate basis

The evaluation of impacts on Bay Region hydrodynamics that are associated with the Program alternatives focuses on X2 position and Delta outflow.

DWRSIM model studies provide a preliminary assessment of the magnitude of riverine flow changes that would be expected for each Program alternative and variation. Two locations in the Sacramento River and San Joaquin River Regions (Freeport and Vernalis) were selected as the focal points for analyzing hydraulic changes in the rivers.

DWRSIM model studies also provide a preliminary assessment of releases from existing reservoirs, as well as diversions and releases from new reservoirs.

A 2020 No Action Alternative was defined to represent a reasonable range of uncertainty in the preimplementation condition. This range of uncertainty was quantified for purposes of this programmatic document by formulating two distinct bookend water management criteria assumptions sets.



for assessing the impacts of proposed projects. (See Section 5.2.3 for a description of existing conditions.) However, Program implementation is expected to occur over a 20- to 30-year period. Bay-Delta standards and management criteria, water management facilities, and other conditions are not expected to remain constant over this extended period. The actual deviation between preimplementation conditions and existing conditions is subject to a high degree of uncertainty. Section 5.2.2 elaborates on the uncertainties associated with the Program.

A 2020 No Action Alternative was defined to represent a reasonable range of uncertainty in the preimplementation condition. This range of uncertainty was quantified for purposes of this programmatic document by formulating two distinct bookend water management criteria assumptions sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in the No Action Alternative programmatic analysis. The primary assumptions that differentiate the No Action Alternative bookends from each other (and from existing conditions) are Bay-Delta system water demands and various Delta management criteria that regulate system operations.

Under Criterion A, the Program assumes that existing Bay-Delta system water demands apply throughout the Program planning horizon. Under this assumption, any future increase in demands in the Program study area would be met by alternative supply or demand management options. This bookend of the No Action Alternative also includes more protective Delta management criteria regulating flows and exports. While specific assumptions regarding Delta management criteria were made to complete the water simulation modeling, the Program's intention is to depict a general level of protection. These assumptions should not be interpreted as specific predictions of future Delta management requirements. Criterion A results in generally lower Delta exports than existing conditions.

Under Criterion A, the Program assumes that existing Bay-Delta system water demands apply throughout the Program planning horizon.

Under Criterion B, the Program assumes an increase in Bay-Delta system water demands of about 10% over existing conditions, as projected for 2020 in DWR's Bulletin 160-98. DWR has formed a technical peer review panel to review the Bulletin's urban water forecasting methodologies; however, the Bay-Delta system demands included in Bulletin 160-98 serve as a reasonable upper boundary for 2020 conditions. This bookend of the No Action Alternative includes no change in Delta water management criteria from existing conditions. Criterion B results in generally higher Delta exports than existing conditions. Details regarding assumptions used in the evaluation of the No Action Alternative are presented in Section 5.1.4 and Attachment A.

Under Criterion B, the Program assumes an increase in Bay-Delta system water demands of about 10% over existing conditions, as projected for 2020 in DWR's Bulletin 160-98.

The programmatic comparisons presented in this section differentiate Bay-Delta hydrodynamics and riverine hydraulics under the No Action Alternative and existing conditions for the Delta, Bay, and Sacramento River and San Joaquin River Regions. As discussed in previous sections, riverine hydraulics outside the Central Valley are not expected to be directly affected by any Program alternative.

Most comparisons are made based on a 73-year historical hydrologic period, a sequence of years often referred to as the "long-term" period. Similar comparisons are made using

Most comparisons are made based on a 73-year historical hydrologic period, a sequence of years often referred to as the "long-term" period.



a subset of the long-term period—the dry and critical years. Over the long-term period, 28 years are classified as dry or critical by the Sacramento Valley 40-30-30 Index. Some detailed Delta hydrodynamic analyses, conducted with the Delta hydrodynamic and water quality model DSM2, were conducted using a 16-year historical hydrologic sequence. This period was selected to cover a broad range of Delta inflows and exports, including several dry and critical years, and provides a good representation of the 73-year long-term period.

Comparisons of Bay-Delta hydrodynamics and riverine hydraulics characteristics under both No Action Alternative bookends were made with those same characteristics under existing conditions. For most parameters of interest, existing conditions fall between the two No Action Alternative bookends, within the range of uncertainty associated with the No Action Alternative. This trend applies to both the long-term period and dry and critical years. Specific comparisons of Bay-Delta hydrodynamics and riverine hydraulics characteristics under the No Action Alternative and existing conditions for the Delta, Bay, and Sacramento River and San Joaquin River Regions are presented below.

5.2.6.1 DELTA REGION

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows, water levels, and mass fate throughout the Delta Region. To provide a programmatic overview, this analysis focuses on a few key locations. Channel flows are described at five locations and stage is described at two locations.

Channel Flows

Sacramento River Flow at Rio Vista. The 1995 WQCP specifies minimum flow rates in the Sacramento River at Rio Vista from September through December. The DSM2 analysis shows that in most months, the No Action Alternative provides no substantial change in average monthly Rio Vista flow relative to existing conditions. The analysis does, however, show some reductions in average flow during June and July. Over the long-term period, average monthly flow could decrease by as much as 12-17%. In dry and critical years, average monthly flow could decrease by as much as 30%. A comparison of monthly average Rio Vista flow is provided in Figure 5.2-4 for the long-term period and in Figure 5.2-5 for dry and critical years.

QWEST Flow. Tidal action has a great influence on the flow of water in Delta channels. Over the tidal cycle, flows move downstream toward the Bay during ebb tides and move upstream during flood tides. QWEST is a measure of the net flow direction from the west Delta: positive QWEST values signify net flow from the west Delta downstream toward the Bay, and negative QWEST values signify net flow from the west Delta upstream toward the southern and central Delta. The range of QWEST flows predicted for the No Action Alternative generally bracket flows under existing conditions. Average monthly QWEST flow is negative during August through December over the long-term period. During dry and critical years, average monthly QWEST flow is negative in most months.

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows, water levels, and mass fate throughout the Delta Region. To provide a programmatic overview, this analysis focuses on a few key locations. Channel flows are described at five locations and stage is described at two locations.

Tidal action has a great influence on the flow of water in Delta channels. Over the tidal cycle, flows move downstream toward the Bay during ebb tides and move upstream during flood tides. QWEST is a measure of the net flow direction from the west Delta.

The DCC also has a great influence on the flow of water in Delta channels. Flows through the DCC and Georgiana Slough, collectively referred to as cross-Delta flow, allow for the conveyance of Sacramento River water directly from the north Delta to the central and south Delta.



Figure 5.2-4. Average Monthly Sacramento River Flow at Rio Vista under the No Action Alternative for the Long-Term Period

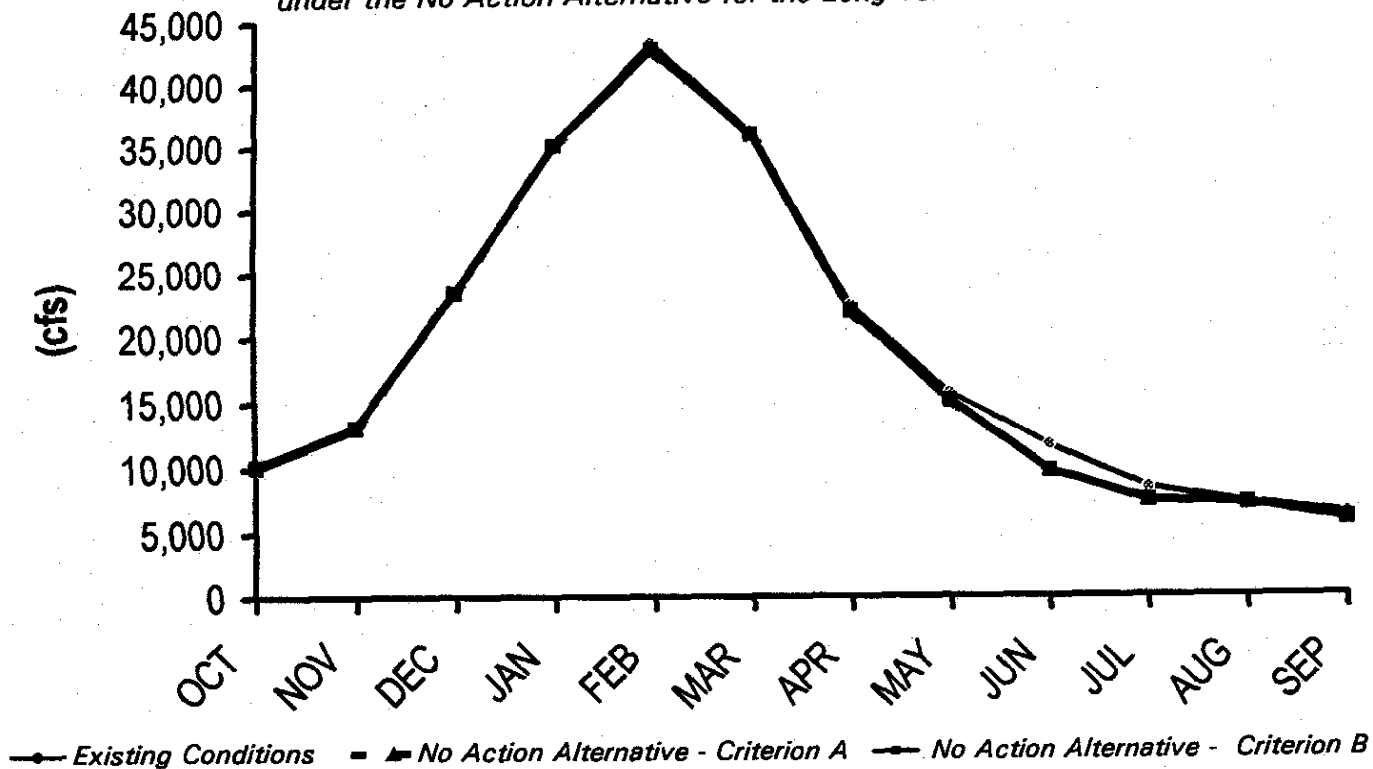
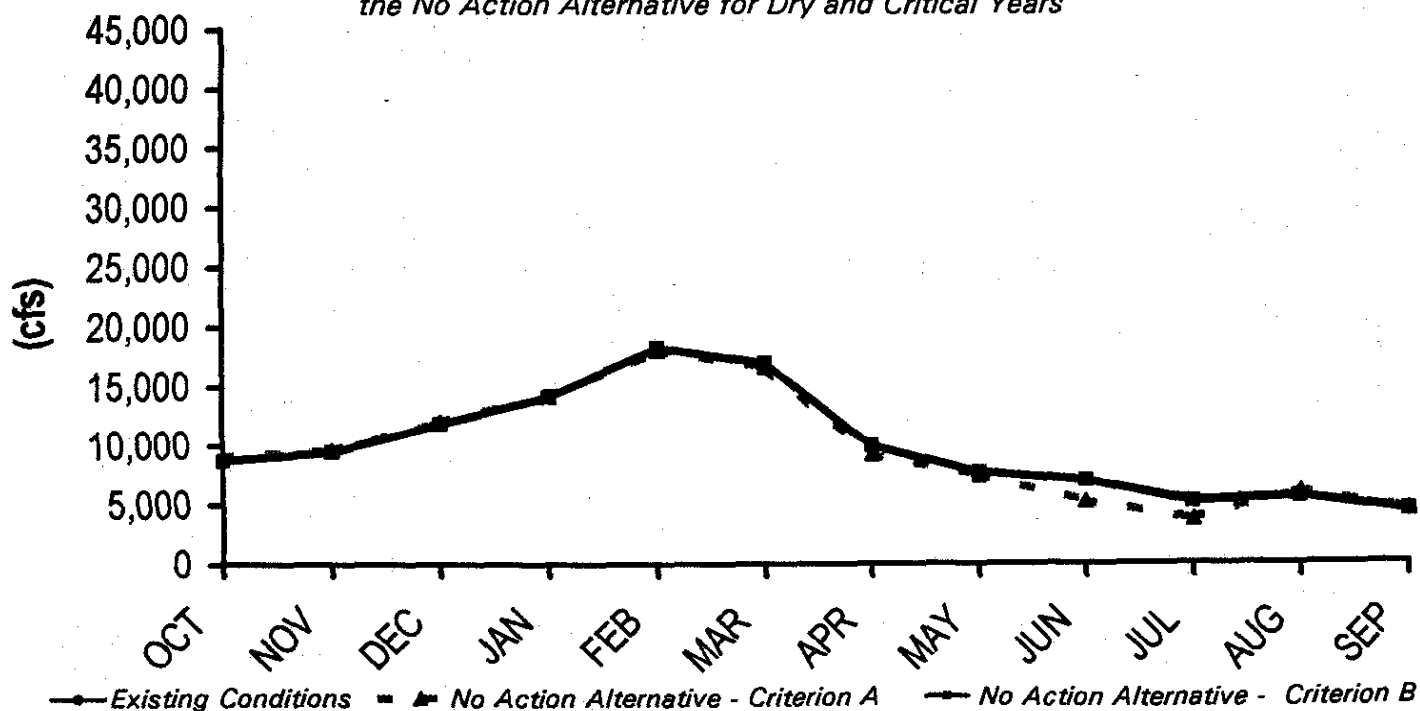


Figure 5.2-5. Average Monthly Sacramento River Flow at Rio Vista under the No Action Alternative for Dry and Critical Years



A comparison of monthly average QWEST flow is provided in Figure 5.2-6 for the long-term period and in Figure 5.2-7 for dry and critical years.

Cross-Delta Flow. The DCC also has a great influence on the flow of water in Delta channels. Flows through the DCC and Georgiana Slough, collectively referred to as cross-Delta flow, allow for the conveyance of Sacramento River water directly from the north Delta to the central and south Delta. Higher cross-Delta flows generally allow for more positive QWEST flows and improved water quality in the central and south Delta. However, operation of the DCC is regulated by the 1995 WQCP and the CVPIA to provide fishery protections. Except during June and July, no substantial change in average monthly cross-Delta flow is expected under the No Action Alternative relative to existing conditions. Over the long-term period, average monthly flow during these months could increase by as much as 7% or could decrease by as much as 10%. In dry and critical years, average monthly flow could decrease by as much as 19%. A comparison of monthly average cross-Delta flow is provided in Figure 5.2-8 for the long-term period and in Figure 5.2-9 for dry and critical years.

The flow of water in Old River at Bacon Island is often used as an indicator of hydraulic conditions in the south Delta.

Old River Flow at Bacon Island. The flow of water in Old River at Bacon Island is often used as an indicator of hydraulic conditions in the south Delta. Average monthly flow is generally negative over the long-term period, ranging from -3,400 to -3,500 cfs in August and from -100 to -1,100 cfs in April. Average monthly flow is always negative in dry and critical years, ranging from -3,000 to -3,600 cfs in August and from -1,000 to -100 cfs in April. The range of Old River flows predicted for the No Action Alternative at Bacon Island generally brackets flows under existing conditions.

Similar to QWEST, the net flow in the San Joaquin River at Antioch is a measure of tidal interactions between the west Delta and the interior Delta.

San Joaquin River Flow at Antioch. Similar to QWEST, the net flow in the San Joaquin River at Antioch is a measure of tidal interactions between the west Delta and the interior Delta. The range of San Joaquin River flows predicted for the No Action Alternative at Antioch generally brackets flows under existing conditions. Average monthly flow is generally positive over the long-term period, ranging from -1,000 to -1,200 cfs in October and from 10,800 to 12,900 cfs in February. Average monthly flow ranges from -2,100 to -2,400 cfs in December and from 2,200 to 3,600 cfs in April of dry and critical years.

Stage

Water levels, or stage, vary greatly during each tidal cycle, from less than 1 foot on the San Joaquin River near I-5 to more than 5 feet near Pittsburg. Adequate water levels are of particular concern for agricultural diverters in the south Delta. About 1,800 agricultural diversions are situated in the Delta. During the peak summer irrigation season, diversions from these facilities collectively exceed 4,000 cfs.

About 1,800 agricultural diversions are situated in the Delta. During the peak summer irrigation season, diversions from these facilities collectively exceed 4,000 cfs.

Middle River Upstream of Victoria Island. Under the No Action Alternative, minimum monthly stage in Middle River upstream of Victoria Island is expected to vary between 0.1 and 0.8 foot below msl over the long-term period. In dry and critical years, minimum monthly stage is expected to vary between 0.5 and 0.7 foot below msl. The No Action Alternative range generally brackets existing condition values.



Figure 5.2-6. Average Monthly QWEST Flow under the No Action Alternative for the Long-Term Period

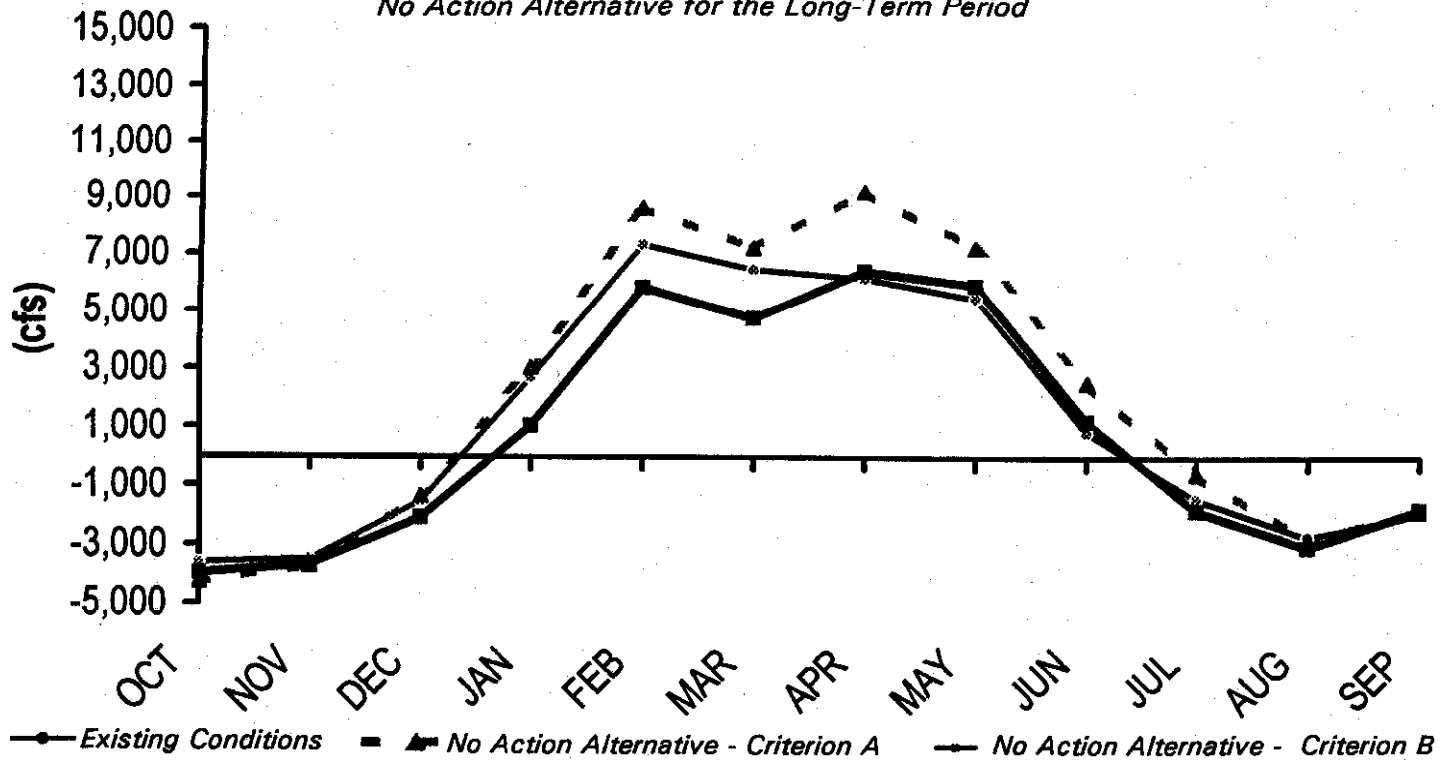


Figure 5.2-7. Average Monthly QWEST Flow under the No Action Alternative for Dry and Critical Years

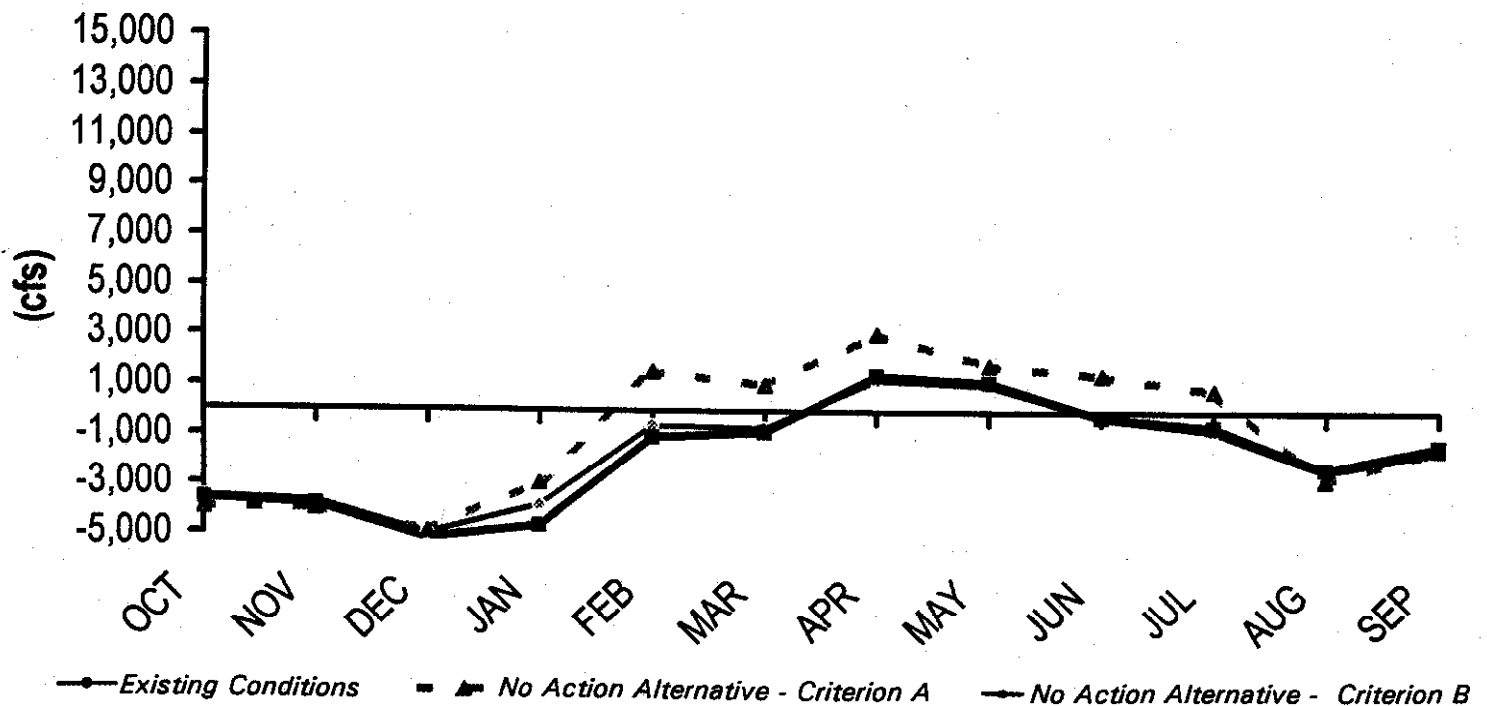


Figure 5.2-8. Average Monthly Cross-Delta Flow under the No Action Alternative for the Long-Term Period

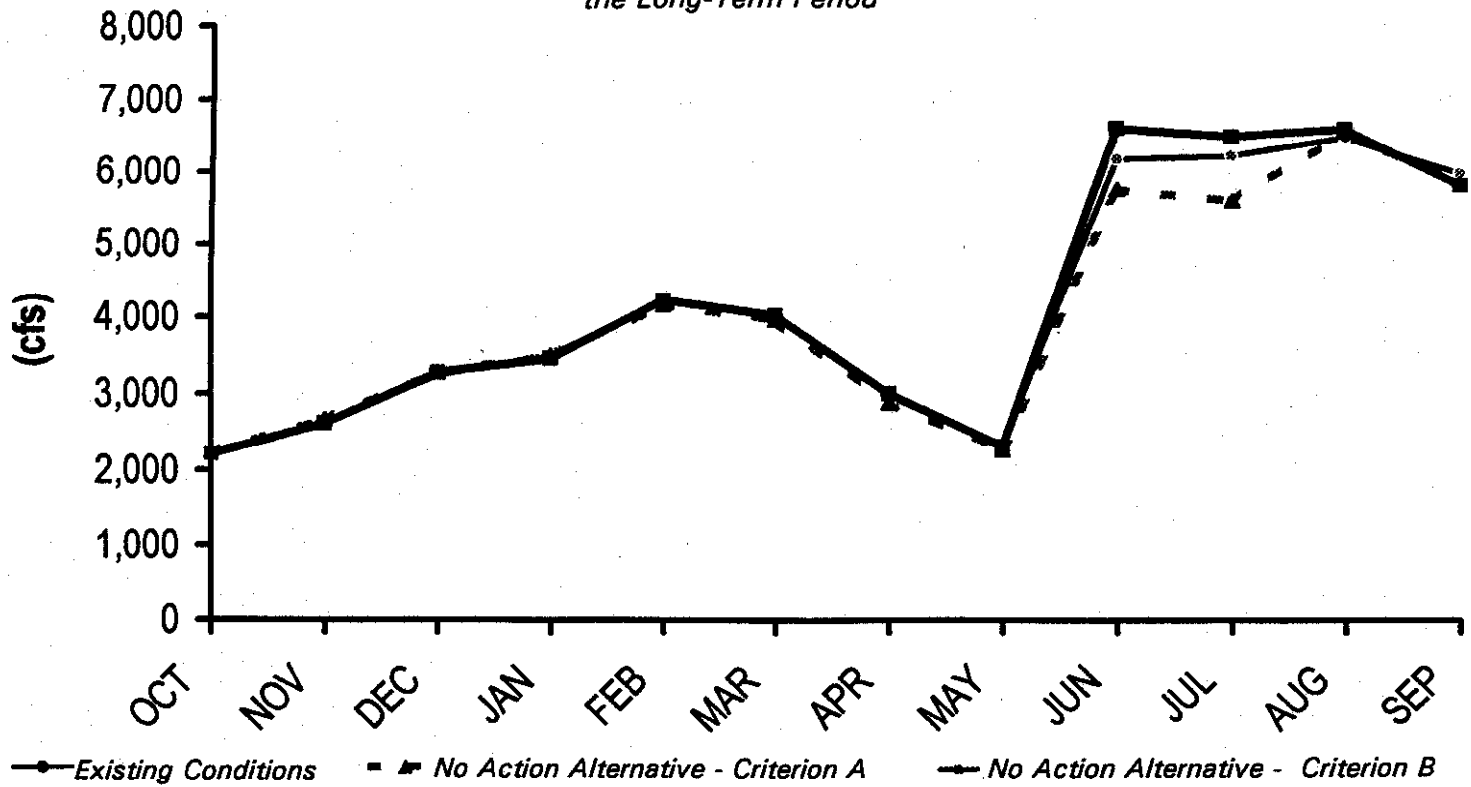
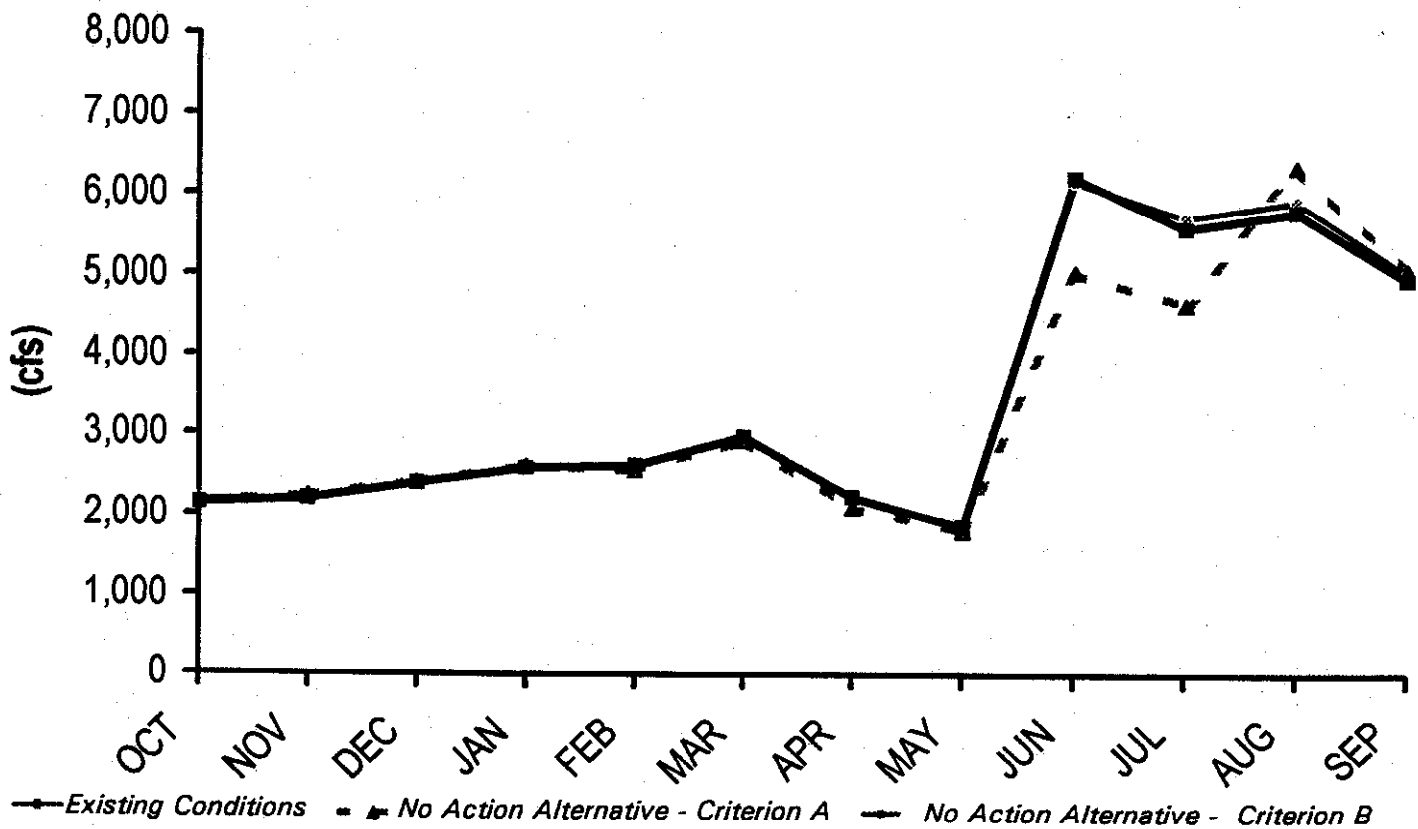


Figure 5.2-9. Average Monthly Cross-Delta Flow under the No Action Alternative for Dry and Critical Years



Old River at Paradise Cut. The No Action Alternative also is expected to result in minimum monthly stage in Old River at Paradise Cut, varying between 0.7 foot below and 0.6 foot above msl over the long-term period. In dry and critical years, minimum monthly stage varies between 0.8 and 0.3 foot below msl. Again, the No Action Alternative range generally brackets existing condition values.

Mass Fate

The DSM2 model was used to perform several mass tracking simulations for existing conditions and the No Action Alternative. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

5.2.6.2 BAY REGION

The 1995 WQCP established fishery protection measures related to X2 position. The CVPIA provides water supplies to further enhance X2 position for environmental benefits. Under the No Action Alternative, monthly average X2 position over the long-term period ranges from a maximum downstream position of 65.3 km in March to a maximum upstream position of 87.0 km in September. The ranges of X2 position predicted for the No Action Alternative generally bracket values under existing conditions.

The 1995 WQCP established fishery protection measures related to X2 position. The CVPIA provides water supplies to further enhance X2 position for environmental benefits.

A comparison of monthly average X2 position is provided in Figure 5.2-10 for the long-term period and in Figure 5.2-11 for dry and critical years. As shown in the figures, the greatest deviations in monthly average values occur in winter. For the long-term period, X2 position could vary by -0.5 to 0.6 km in January and could vary by -0.6 to 0.5 km in February. In dry and critical years, X2 position could decrease by as much as 1.2 km or increase as much as 0.1 km in March relative to existing conditions.

5.2.6.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Programmatic comparisons of river flows and reservoir releases in the Sacramento River and San Joaquin River Regions were made between the No Action Alternative and existing conditions using DWRSIM modeling results. Differences generally fall within the range of uncertainty associated with the No Action Alternative.

River Flows. Flows from the Sacramento River Region enter the Delta just south of Sacramento at Freeport. Under the No Action Alternative, average monthly flow in the Sacramento River at Freeport is expected to vary seasonally between 11,900 cfs in September and 38,100 cfs in February over the long-term period. Average monthly flow is expected to vary seasonally between 9,800 cfs in September and 20,700 cfs in February for dry and critical years. In most months, no substantial change in average flow is

Programmatic comparisons of river flows and reservoir releases in the Sacramento River and San Joaquin River Regions were made between the No Action Alternative and existing conditions using DWRSIM modeling results. Differences generally fall within the range of uncertainty associated with the No Action Alternative.



Figure 5.2-10. Average Monthly X2 Position under the No Action Alternative for the Long-Term Period

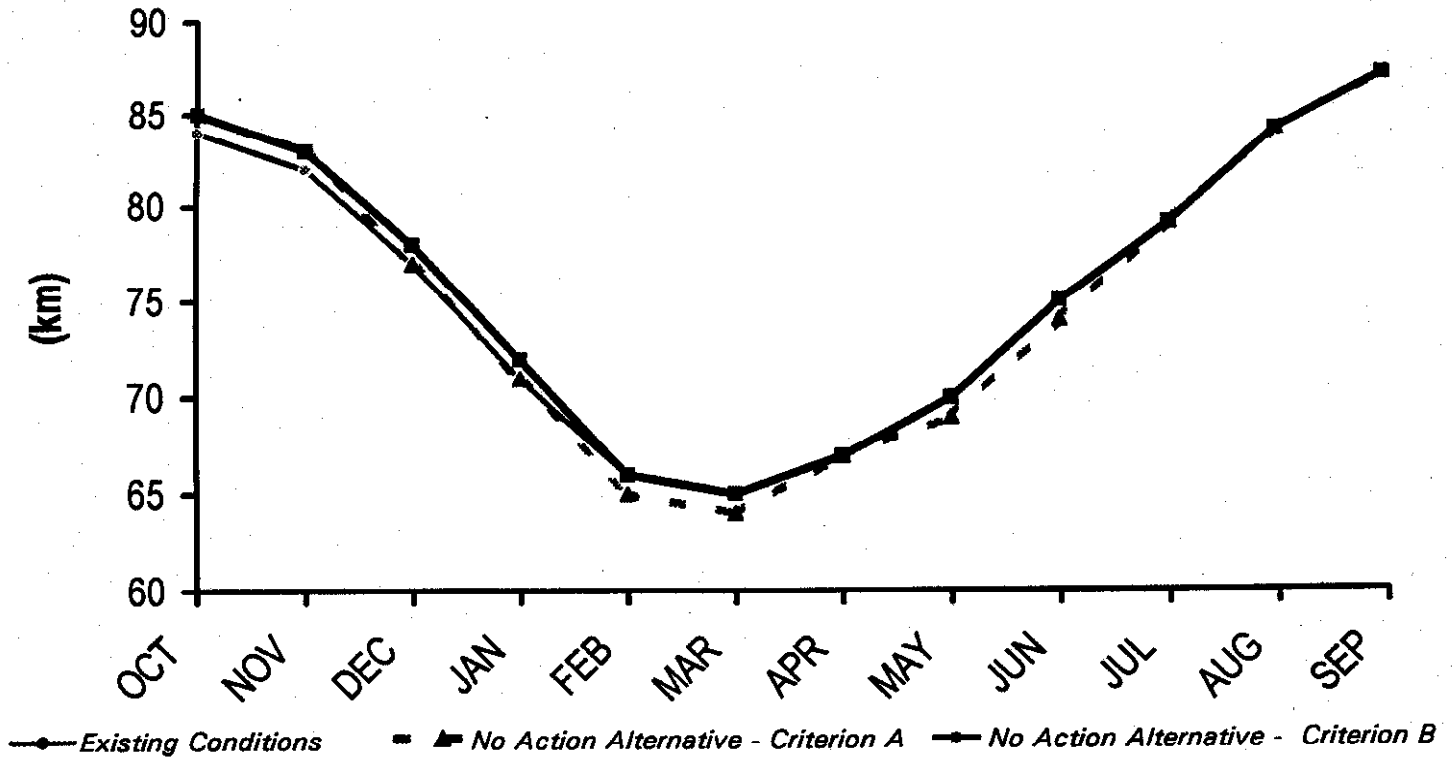
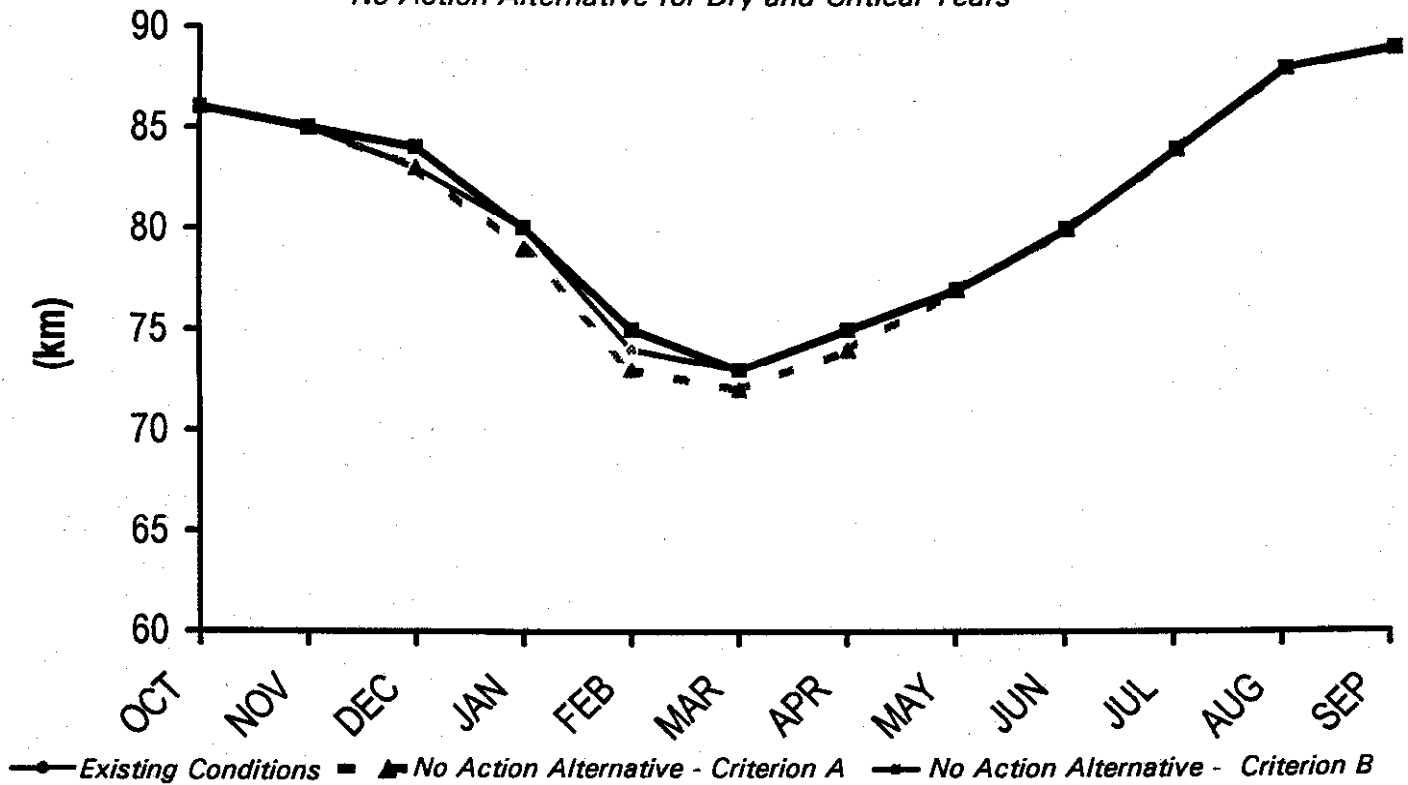


Figure 5.2-11. Average Monthly X2 Position under the No Action Alternative for Dry and Critical Years



expected under the No Action Alternative relative to existing conditions. However, some reductions in average flow could occur during June and July. Over the long-term period, average monthly flow could decrease by about 12% in these months. In dry and critical years, average monthly flow could decrease by about 18%. A comparison of monthly average Sacramento River flow at Freeport is provided in Figure 5.2-12 for the long-term period and in Figure 5.2-13 for dry and critical years.

Flows from the San Joaquin River Region enter the Delta at Vernalis. Under the No Action Alternative, average monthly flow in the San Joaquin River at Vernalis is expected to vary between 1,600 cfs in August and 6,200 cfs in April over the long-term period. Average monthly flow is expected to vary between 1,100 cfs in August and 2,900 cfs in April for dry and critical years. Although average annual San Joaquin River flow at Vernalis is expected to be similar under existing conditions and the No Action Alternative, some changes in monthly flow patterns are predicted by the analysis. Over the long-term period relative to existing conditions, the No Action Alternative is expected to result in lower average Vernalis flow in January through March (by about 4%) and higher average Vernalis flow in April through June (by about 8%). In dry and critical years, the No Action Alternative is expected to result in somewhat higher flows relative to existing conditions in December through April. During these months, average flows may increase in the range of 3-9%. A comparison of monthly average San Joaquin River flow at Vernalis is provided in Figure 5.2-14 for the long-term period and in Figure 5.2-15 for dry and critical years.

Flows from the San Joaquin River Region enter the Delta at Vernalis.

Existing Reservoir Releases. Average monthly releases from Sacramento River Region surface reservoirs are similar under existing conditions and the No Action Alternative. Average releases vary between 9,400 cfs in October and 22,600 cfs in July over the long-term period. In dry and critical years when winter flood control releases are not typically made, average releases vary between 7,000 cfs in January and 18,300 cfs in July.

Average monthly releases from San Joaquin River Region surface reservoirs are expected to vary somewhat between the No Action Alternative and existing conditions. While monthly releases are similar in dry and critical years, the programmatic analysis shows small variations occurring between January and June over the long-term period. No Action Alternative reservoir releases are about 1% lower during winter and 3-5% higher during spring. Average releases vary between 1,600 cfs in November and 8,500 cfs in May over the long-term period. In dry and critical years, average flows vary between 800 cfs in January and 6,100 cfs in May.



5.2.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

For Bay-Delta hydrodynamics and riverine hydraulics, the environmental consequences of the Ecosystem Restoration, Levee System Integrity, Water Use Efficiency, and Water Transfer Program elements are similar under all Program alternatives and are described by study area in this section. The environmental consequences of the Storage and Conveyance element vary among Program alternatives, as described in Section 5.2.8. The Water Quality and Watershed Program elements would not substantially affect hydraulics and hydrodynamics in the Program study area, as discussed below.

The Water Quality Program would not directly affect river hydraulics or hydrodynamics. However, where timed releases are made to dilute harmful constituent loadings, small changes in streamflow patterns and hydraulic characteristics may result. The effects of the Water Quality Program are not discussed further in this section.

The various possible watershed projects proposed under the Watershed Program would alter flow regimes in specific areas. Effects of these flow changes in the Delta and the Bay Regions should be negligible. Vegetation and habitat restoration projects may increase retention of surface water in the watershed, but the effects on hydrodynamics also should be very small. The effects of the Watershed Program in the Delta and Bay Regions are not discussed further in this section.

The Water Quality Program would not directly affect river hydraulics or hydrodynamics. However, where timed releases are made to dilute harmful constituent loadings, small changes in streamflow patterns and hydraulic characteristics may result.

The various possible watershed projects proposed under the Watershed Program would alter flow regimes in specific areas. Effects of these flow changes in the Delta and the Bay Regions should be negligible.

5.2.7.1 DELTA REGION

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program would increase spring flows during 10-day pulse flow periods within rivers of the Central Valley and the Delta. Under the Ecosystem Restoration Program, Delta outflow would be augmented by a pulse flow originating in the Sacramento River watershed in March and again by a pulse flow originating in the San Joaquin River watershed in late April or early May. Flows would be augmented primarily in above-normal, below-normal, and dry water years. Over the long-term period, Delta outflow would be increased during these pulse flow periods (in total) by an average of about 300 TAF.

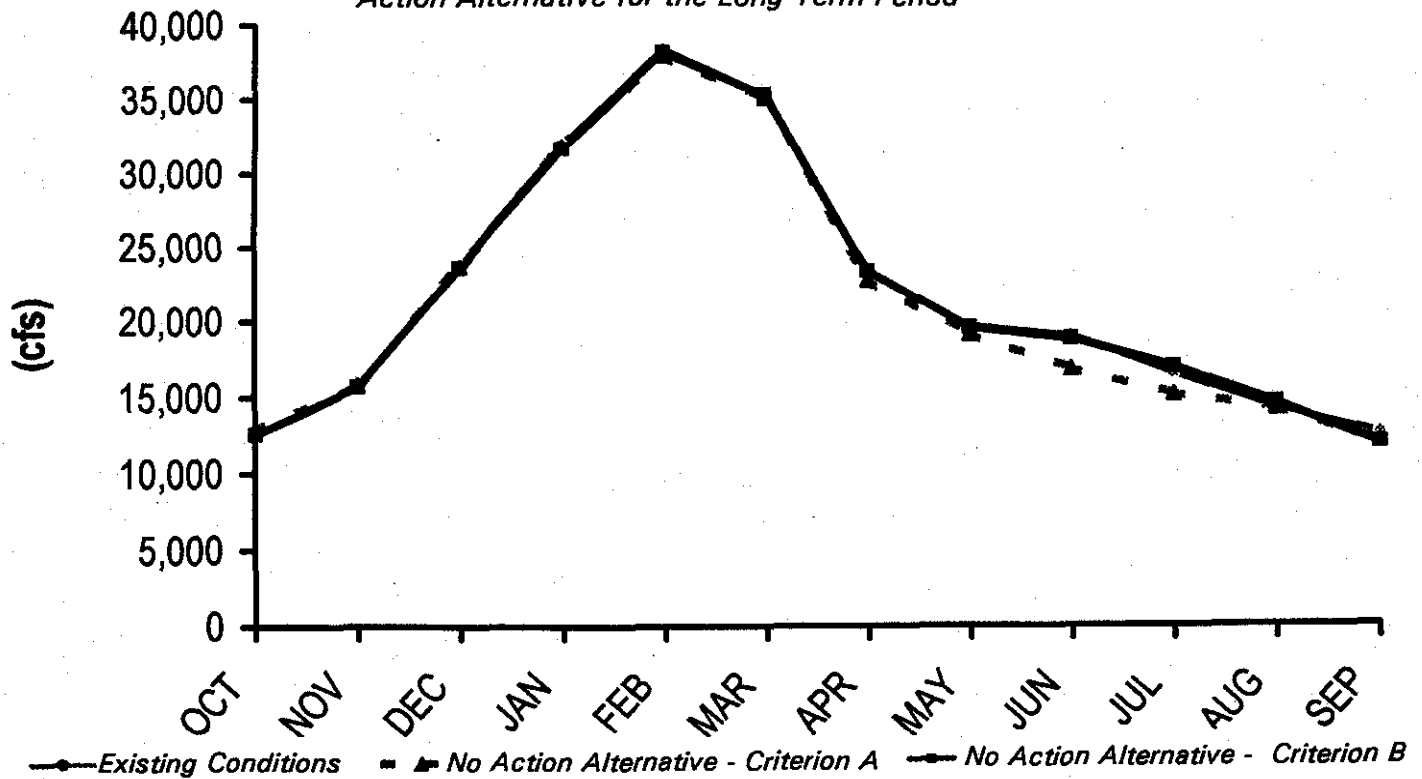
Implementation of the Ecosystem Restoration Program would increase spring flows during 10-day pulse flow periods within rivers of the Central Valley and the Delta.

Levee System Integrity Program

Channel geometry may be altered by creating setback levees, dredging channels for levee construction material, or increasing the height of levees. Increased levee heights, channel widening and deepening, and bank stabilization could result in increased channel



Figure 5.2-12. Average Monthly Sacramento River Flow at Freeport under the No Action Alternative for the Long-Term Period



5.2-13. Average Monthly Sacramento River Flow at Freeport under the No Action Alternative for Dry and Critical Years

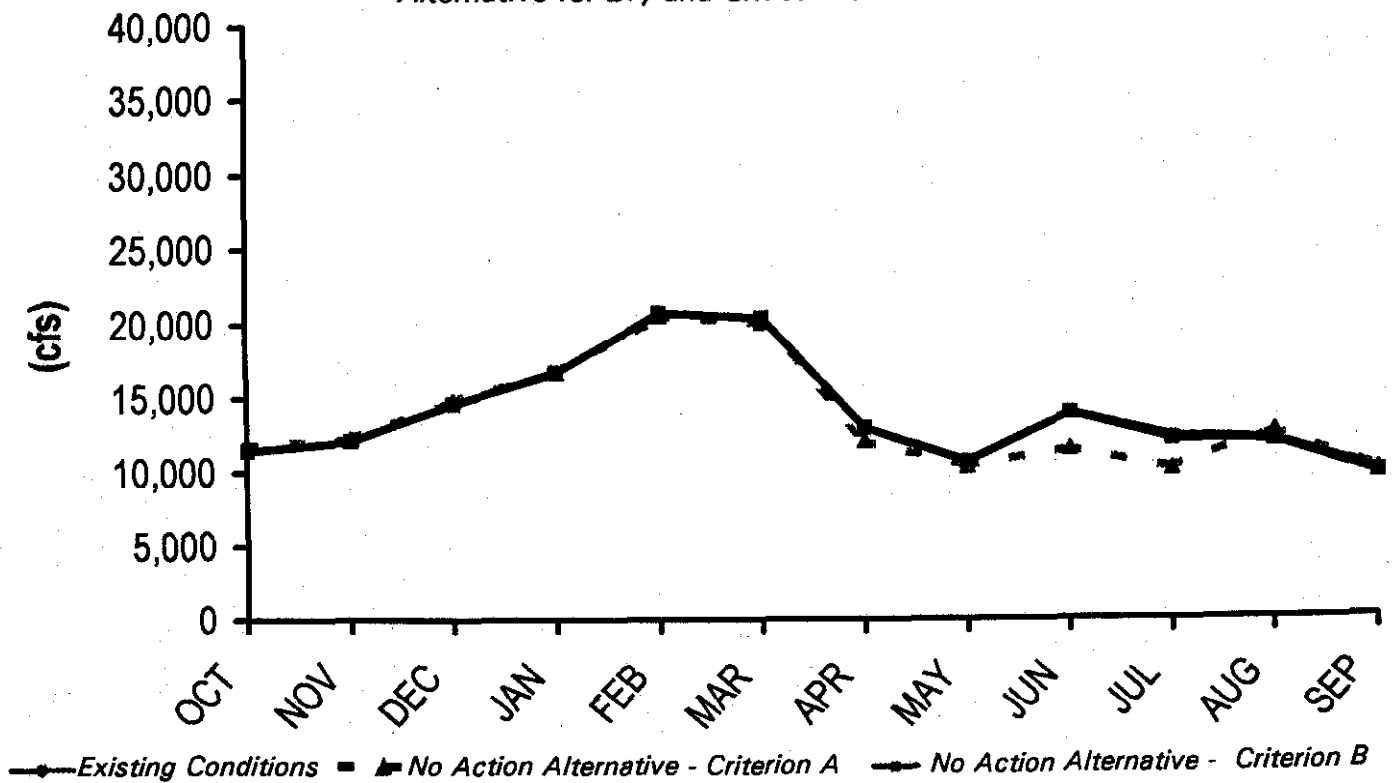


Figure 5.2-14. Average Monthly San Joaquin River Flow at Vernalis under the No Action Alternative for the Long-Term Period

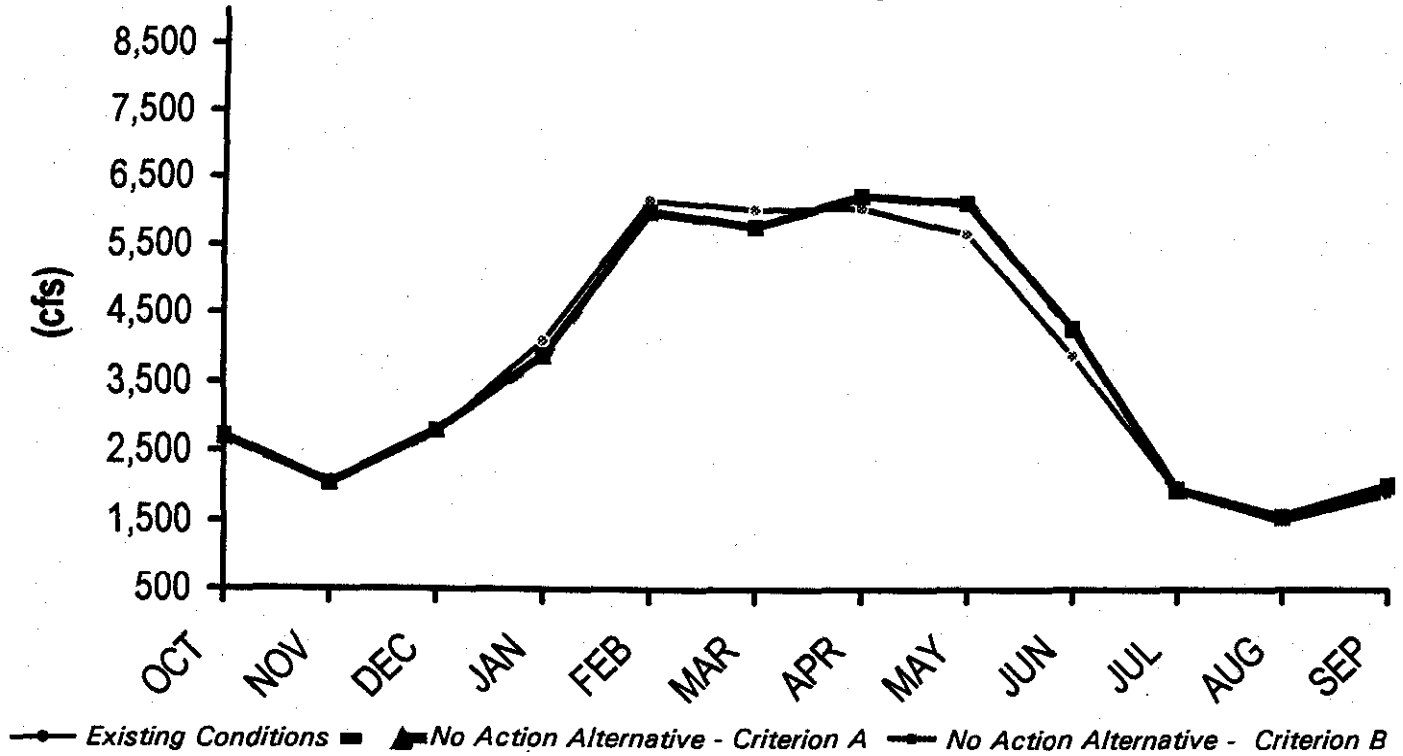
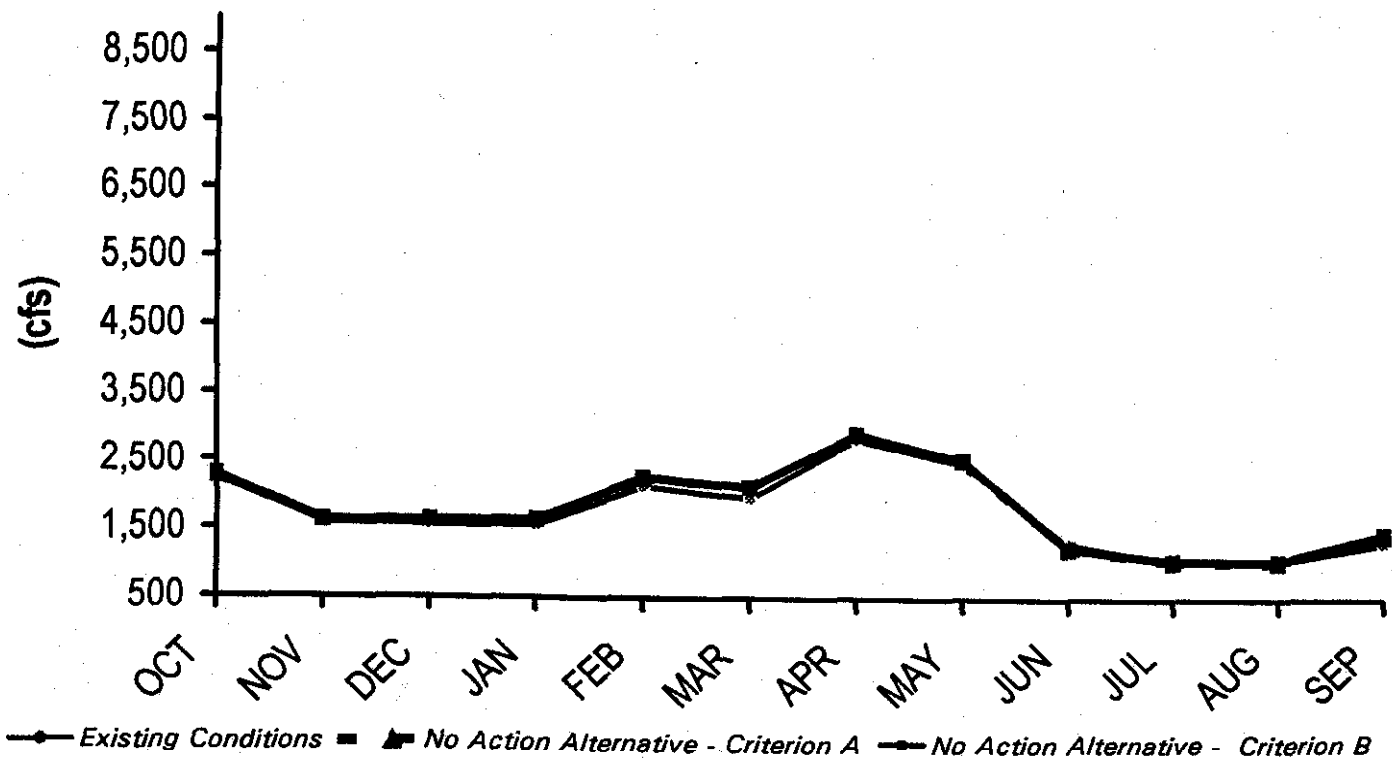


Figure 5.2-15. Average Monthly San Joaquin River Flow at Vernalis under the No Action Alternative for Dry and Critical Years



capacities. Channel widening would reduce stream and channel velocities at the selected sites. This would create the potential for more sediment deposition, with both positive and negative environmental consequences.

Since the Levee System Integrity Program focuses on levee improvements and modifications within the Delta, any potential adverse impacts on channel hydraulic characteristics outside the Delta are expected to be minor. Therefore, this program is discussed only for the Delta Region.

Channel widening would reduce stream and channel velocities at the selected sites. This would create the potential for more sediment deposition, with both positive and negative environmental consequences.

Water Use Efficiency Program

Increasing water use efficiency could affect Delta hydrodynamics by changing the timing of diversions and reducing the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. These effects are expected to be small and were included within the range of assumptions considered in the Program alternatives system operations modeling.

Water Transfer Program

Water transfers would affect Delta hydrodynamics primarily through changes to Delta inflows and water temperature. Increased water transfers could change the timing of diversions and alter the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. Water transfers from areas upstream of the Delta to areas south of the Delta would affect Delta hydrodynamics by increasing diversions from the Delta and/or modifying water diversion schedules. Management of the Environmental Water Account (EWA) may magnify the effects of this program.

Water transfers from areas upstream of the Delta to areas south of the Delta would affect Delta hydrodynamics by increasing diversions from the Delta and/or modifying water diversion schedules.

5.2.7.2 BAY REGION

Ecosystem Restoration Program

Under the Ecosystem Restoration Program, the acreage of shallow-water aquatic habitat and saline emergent wetlands would be increased adjacent to Suisun Bay and Marsh, San Pablo Bay, the Napa and Petaluma Rivers, and Sonoma Creek. The proposed lands for conversion are currently used for agriculture. These changes could result in a small effect on Bay hydrodynamics.

Under the Ecosystem Restoration Program, the acreage of shallow-water aquatic habitat and saline emergent wetlands would be increased adjacent to Suisun Bay and Marsh, San Pablo Bay, the Napa and Petaluma Rivers, and Sonoma Creek.

Water Use Efficiency Program

Increasing water use efficiency could affect Bay hydrodynamics by changing the timing of diversions and reducing the amounts of water diverted from the Delta for agricultural, municipal, industrial, and ecosystem purposes. This change would alter inflows from the



Delta. Implementation of the Water Use Efficiency Program also would reduce the water returns from agricultural and urban users. These effects are expected to be small.

Water Transfer Program

Water transfers would affect Bay hydrodynamics primarily through changes to river flow and water temperatures. Increased water transfers could change the timing of diversions and alter the amounts of water diverted for agricultural, municipal, industrial, and ecosystem purposes. Water transfers from areas upstream of the Delta to areas south of the Delta could affect Bay hydrodynamics by increasing diversions from the Delta and/or modifying Delta water diversion schedules, thereby affecting outflows to the Bay. Management of the EWA may magnify the effects of this program.

Increasing water use efficiency could affect Bay hydrodynamics by changing the timing of diversions and reducing the amounts of water diverted from the Delta for agricultural, municipal, industrial, and ecosystem purposes.

5.2.7.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

Ecosystem Restoration Program

Implementation of the Ecosystem Restoration Program would increase spring flows during 10-day pulse flow periods within rivers of the Central Valley and the Delta. Under the Ecosystem Restoration Program, pulse flows would occur in the Sacramento River watershed in March and in the San Joaquin River watershed in late April or early May. Flows would be augmented primarily in above-normal, below-normal, and dry water years. Over the long-term period, Sacramento River flows would be increased during these pulse flow periods by an average of about 110 TAF, while San Joaquin River flows would be increased by an average of about 95 TAF.

The Ecosystem Restoration Program could result in short-term adverse impacts from increased sediment loading during construction activities. Conversion of cultivated land to wetlands could increase water use. Reductions in channel velocities in some Delta reaches that are widened to encourage meanders could result in increases in water temperature.

The Ecosystem Restoration Program could result in short-term adverse impacts from increased sediment loading during construction activities. Conversion of cultivated land to wetlands could increase water use. Reductions in channel velocities in some Delta reaches that are widened to encourage meanders could result in increases in water temperature.

Water Use Efficiency Program

Improved water use efficiency could alter the timing and reduce the amount of water diverted to supply agricultural, urban, and ecosystem uses. These changes could affect riverine hydraulics by reducing the number and size of diversions, and result in the redistribution of reservoir releases. Increased conservation and water recycling in the urban sector could reduce or eliminate the need for increased diversions as populations increase and demand grows. These changes would benefit streamflows overall, but detrimental instream flow reductions could occur in cases where streams are partially or entirely fed by return flows.

Increased conservation and water recycling in the urban sector could reduce or eliminate the need for increased diversions as populations increase and demand grows. These changes would benefit streamflows overall, but detrimental in-stream flow reductions could occur in cases where streams are partially or entirely fed by return flows.



Water Transfer Program

Water transfers can modify the timing and/or increase or decrease streamflows in channels. The timing and magnitude of the changes in flows would be constrained by facility conveyance capacities such as those of the Delta export pumps and canals south of the Delta, and by system operating rules. Management of the EWA may magnify the effects of this program.

Water transfers can modify the timing and/or increase or decrease streamflows in channels.

Watershed Program

Coordination of watershed activities, as proposed in the Watershed Program, would help facilitate projects that could lead directly or indirectly to changes in channel hydraulics. Two goals of such changes would be improvements to watershed hydrology and to in-stream flow conditions. Effects in the watersheds should be beneficial, and various secondary impacts could occur. Flow changes in trunk streams downstream of most watershed improvement projects generally would be minor. Any residual effects should be moderated by reservoir operations.

Depending on the size and scale of the watershed projects, effects could range from very limited changes in flows in nearby stream reaches, to large-scale changes in flow regimes. Vegetation and habitat restoration projects may increase retention of surface water in the watershed, resulting in less variable runoff (reduced peak flows and increased base flows in streams).

Depending on the size and scale of the watershed projects, effects could range from very limited changes in flows in nearby stream reaches, to large-scale changes in flow regimes. Vegetation and habitat restoration projects may increase retention of surface water in the watershed, resulting in less variable runoff (reduced peak flows and increased base flows in streams).

Improvements in timber harvesting practices could reduce peak flows from affected forested areas, especially during floods. Total annual runoff could be reduced if net evapotranspiration (ET) increases in the target watersheds. Reforestation could produce increases in net ET and reduce annual stream discharges. Other hydrologic variables that could interact to alter stream hydrographs include interception and infiltration of precipitation, surface runoff, groundwater recharge, and stream accretions and depletions. In areas where snowmelt plays an important role in the flow regime, reduced timber harvesting would increase shading and reduce evaporation and sublimation of snow packs to maintain snow packs longer. This would increase net runoff and retard spring runoff peaks. Grazing range improvement activities could increase vegetative cover in watersheds and help to reestablish riparian habitat. Overall effects on watershed hydrologic characteristics would be improved by reducing runoff velocities and increasing water retention. However, annual stream discharges could decrease.

Erosion control efforts could result in reductions and retardation of runoff and sediment transport into tributaries and reservoirs. Because many erosion control efforts are expected to be local and small-scale, efforts would slightly reduce peak flows but would not substantially alter the timing of those flows. Large-scale watershed improvements, such as revegetation of large tracts in steep, denuded watersheds, would result in more substantial beneficial effects.

Erosion control efforts could result in reductions and retardation of runoff and sediment transport into tributaries and reservoirs.



Stream restoration projects, such as the removal of logs and debris from stream channels to improve their fish passage capacities, could result in local increases in flow velocities and erosion while the stream gradient and banks become stable. These impacts would decrease with time and distance downstream, and generally would be negligible.

5.2.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

Quantitative methods were used to predict changes in Bay-Delta hydrodynamics and riverine hydraulics as a result of the implementation of Program elements. The impacts of Program alternatives were analyzed with DWR's operations planning model (DWRSIM) and Bay-Delta hydrodynamic model (DSM2).

Because of the inherent difficulty in projecting conditions that will influence future water management decisions, the Program considered a reasonable range of uncertainty in this programmatic evaluation of alternatives. This range of uncertainty was quantified by formulating two distinct bookend water management criteria assumption sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export and outflow patterns in the No Action Alternative and Program alternatives. Further details regarding the modeling assumptions are presented in Section 5.1.4.

The programmatic comparisons presented in this section differentiate Bay-Delta hydrodynamics and riverine hydraulics resulting under the Program alternatives and the No Action Alternative. These comparisons are made in consideration of ranges of assumptions regarding future water management actions effecting the Bay-Delta system. The water management criteria for the No Action Alternative include ranges of water demands and protective Delta management criteria. The range of water demands represents uncertainty in the future need for Bay-Delta water supplies due to uncertainty in projections of population, land use, implementation of water use efficiency measures, and the effects of water marketing. The range of protective Delta management criteria represents uncertainty related to future actions required to assure recovery of the Bay-Delta ecosystem. It is anticipated that the future conditions will be within the range of water demands and Delta management criteria used to predict impacts.

This section describes Program-induced changes in hydraulic parameters, including flow, stage, and other variables such as X2 position. However, the significance or environmental implications of these changes are not described here. The significance of these changes is addressed in other sections of this report in the context of each of the resources affected by the changes. This section differentiates conditions for the Delta, Bay, Sacramento River, and San Joaquin River planning regions. As discussed previously, riverine hydraulics outside the Central Valley are not expected to be directly affected by any Program alternatives. Changes in streamflows in these service areas would be the

Quantitative methods were used to predict changes in Bay-Delta hydrodynamics and riverine hydraulics as a result of the implementation of Program elements. Because of the inherent difficulty in projecting conditions that will influence future water management decisions, the Program considered a reasonable range of uncertainty in this programmatic evaluation of alternatives.

The range of water demands represents uncertainty in the future need for Bay-Delta water supplies due to uncertainty in projections of population land use, implementation of water use efficiency measures, and the effects of water marketing. The range of protective Delta management criteria represents uncertainty related to future actions required to assure recovery of the Bay-Delta ecosystem.



result of local interagency operations, were not evaluated by the Program, and are not discussed further in this section.

5.2.8.1 ALTERNATIVE 1

Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross-Delta, Old River at Bacon Island, and San Joaquin River at Antioch), water levels (stage), and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, this analysis focuses on a few key locations. Channel flows are described at five locations and stage is described at two locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs. Under Alternative 1, average monthly Rio Vista flow decreases by as much as 1,000 cfs in February. Alternative 1 modifies flow by -100 to 300 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occurs in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years,

Alternative 1 decreases flow in February by about 150 cfs. In September, Alternative 1 increases flow by as much as 900 cfs. Figures 5.2-16 and 5.2-17 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

QWEST Flow. QWEST flow was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about -4,000 to -4,300 cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400 to 3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from -4,900 to -5,200 cfs.



Figure 5.2-16. Average Monthly Sacramento River Flow at Rio Vista under Alternative 1 for the Long-Term Period

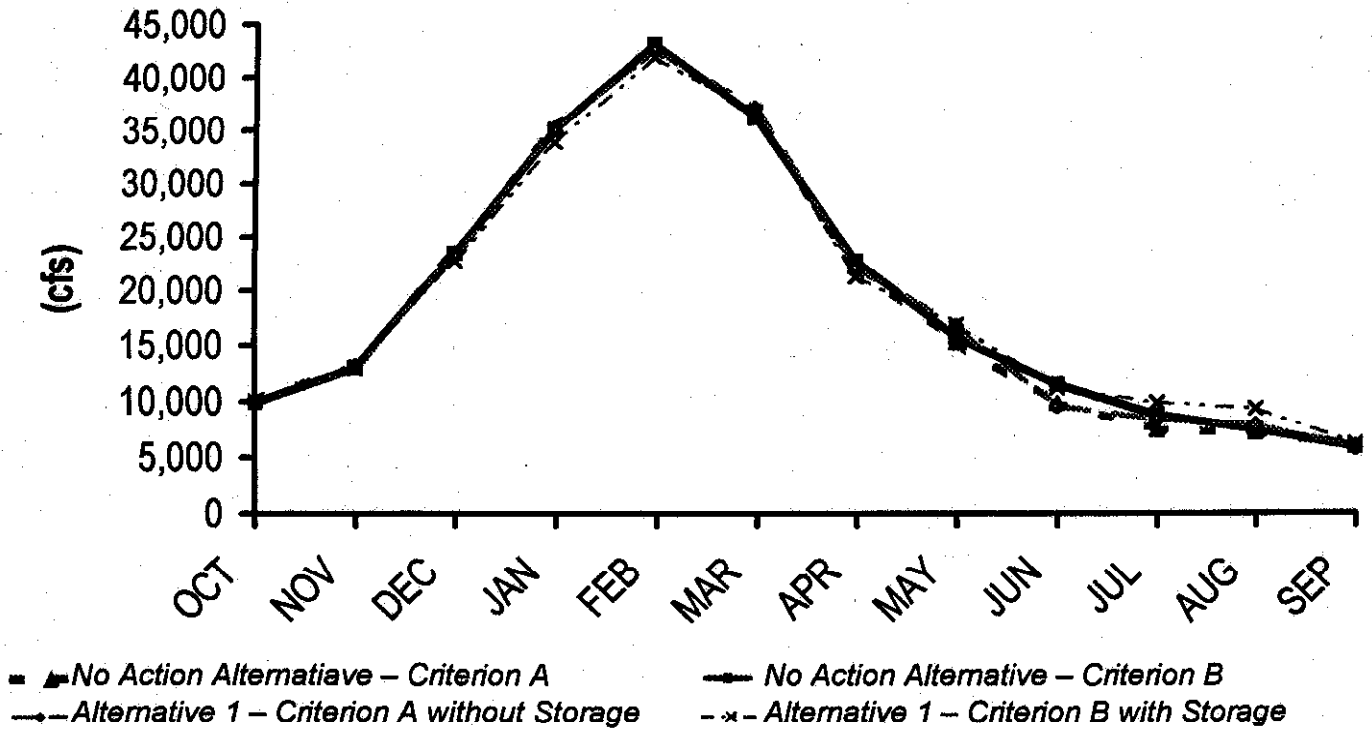
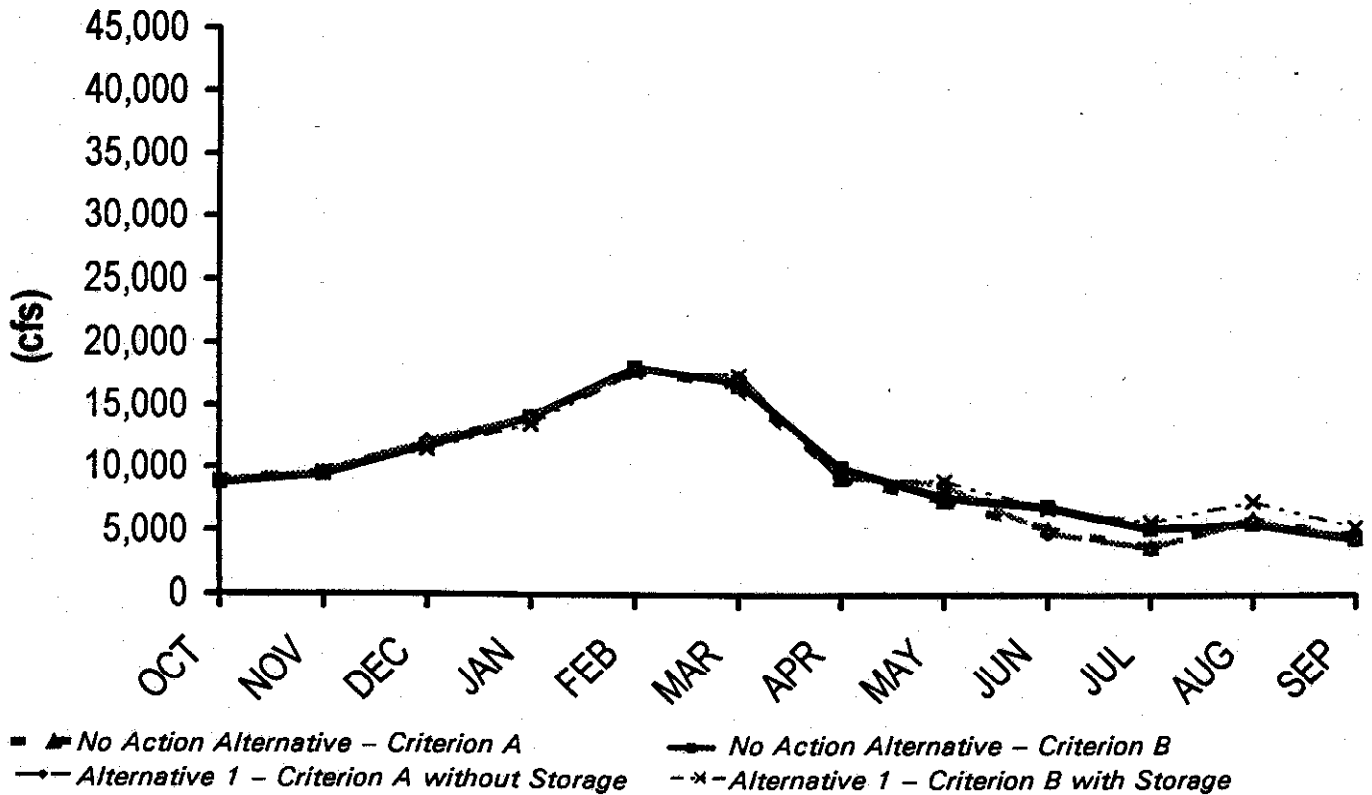


Figure 5.2-17. Average Monthly Sacramento River Flow at Rio Vista under Alternative 1 for Dry and Critical Years



Alternative 1 decreases average monthly positive QWEST flow over the long-term period in April by as much as 500 cfs and increases average monthly reverse QWEST flow in October by as much as 600 cfs. During dry and critical years, Alternative 1 increases average monthly positive QWEST flow in April by only about 10 cfs and increases average monthly reverse QWEST flow in December by as much as 1,000 cfs. Figures 5.2-18 and 5.2-19 compare average monthly QWEST flow for the long-term period and dry and critical years, respectively.

Cross-Delta Flow. Cross-Delta flow was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Differences in cross-Delta flow are best summarized by flows occurring in August, December, and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December, and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, 2,400 cfs in December and 1,800 cfs in May.

Under Alternative 1, over the long-term period and in dry and critical years, cross-Delta flow typically increases in August and May, whereas cross-Delta flow in December may slightly increase or decrease. Over the long-term period under Alternative 1, cross-Delta flow may increase by as much as 600 cfs in August and by about 30 cfs in May relative to the No Action Alternative. Cross-Delta flow in December varies by -30 to 10 cfs relative to the No Action Alternative. During dry and critical years under Alternative 1, cross-Delta flow may increase by about 200 cfs in August and by about 80 cfs in May relative to the No Action Alternative. Cross-Delta flow in December varies by -10 to 10 cfs relative to the No Action Alternative. Figures 5.2-20 and 5.2-21 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about -3,400 cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from -3,000 to -3,600 cfs.

Over the long-term period under Alternative 1, increases in reverse flow in Old River at Bacon Island in August range from 600 to 1,100 cfs, resulting in flow ranging from -4,000 to -4,600 cfs. In dry and critical years under Alternative 1, reverse flow in August may decrease by 100 cfs or may increase by 500 cfs, resulting in flow ranging from -3,400 to -4,000 cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for Alternative 1 and the No Action Alternative for the long-term period and dry and critical years.

Alternative 1 decreases average monthly positive QWEST flow over the long-term period in April by as much as 500 cfs and increases average monthly reverse QWEST flow in October by as much as 600 cfs.

Under Alternative 1, over the long-term period and in dry and critical years, cross-Delta flow typically increases in August and May, whereas cross-Delta flow in December may slightly increase or decrease.

Over the long-term period under Alternative 1, increases in reverse flow in Old River at Bacon Island in August range from 600 to 1,100 cfs, resulting in flow ranging from -4,000 to -4,600 cfs.



Figure 5.2-18. Average Monthly QWEST Flow under Alternative 1 for the Long-Term Period

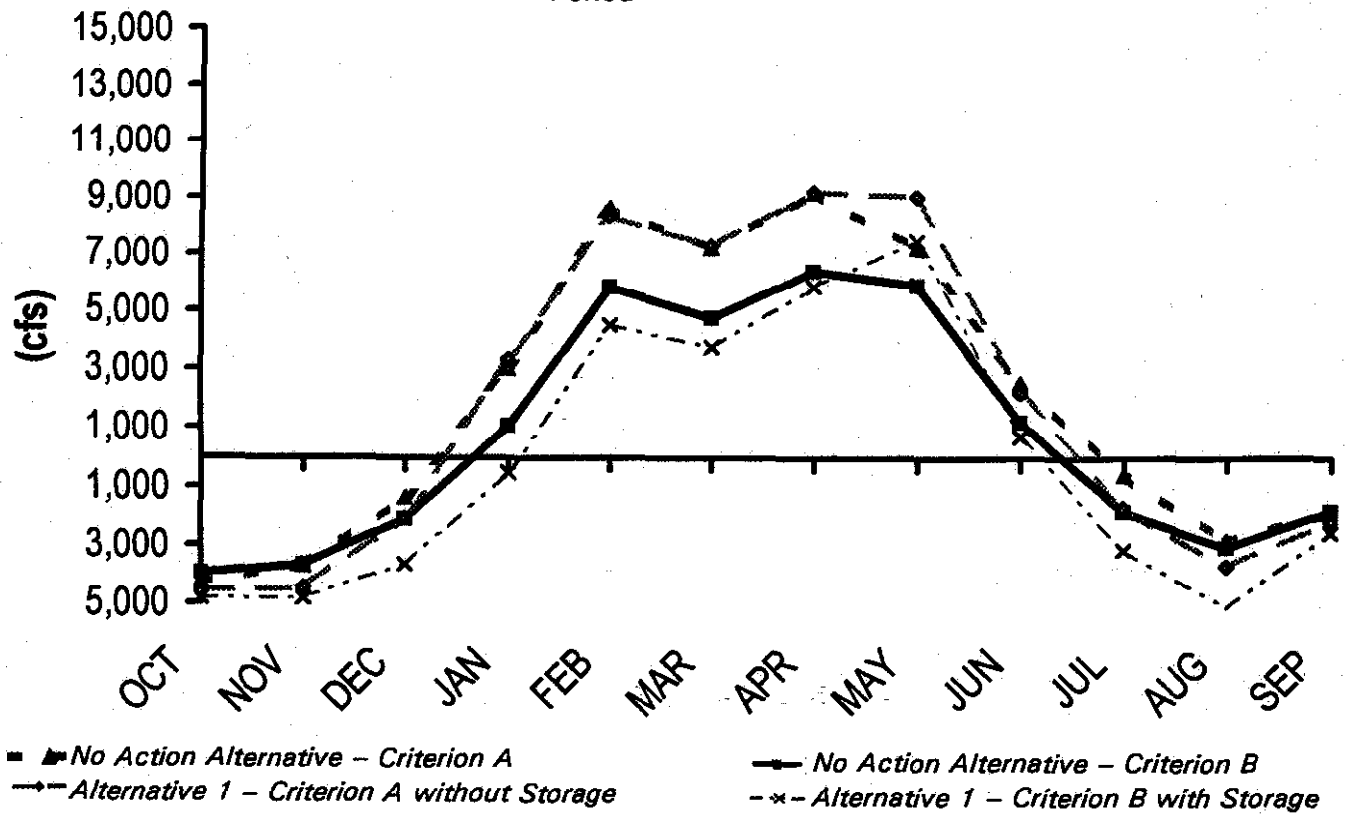


Figure 5.2-19. Average Monthly QWEST Flow under Alternative 1 for Dry and Critical Years

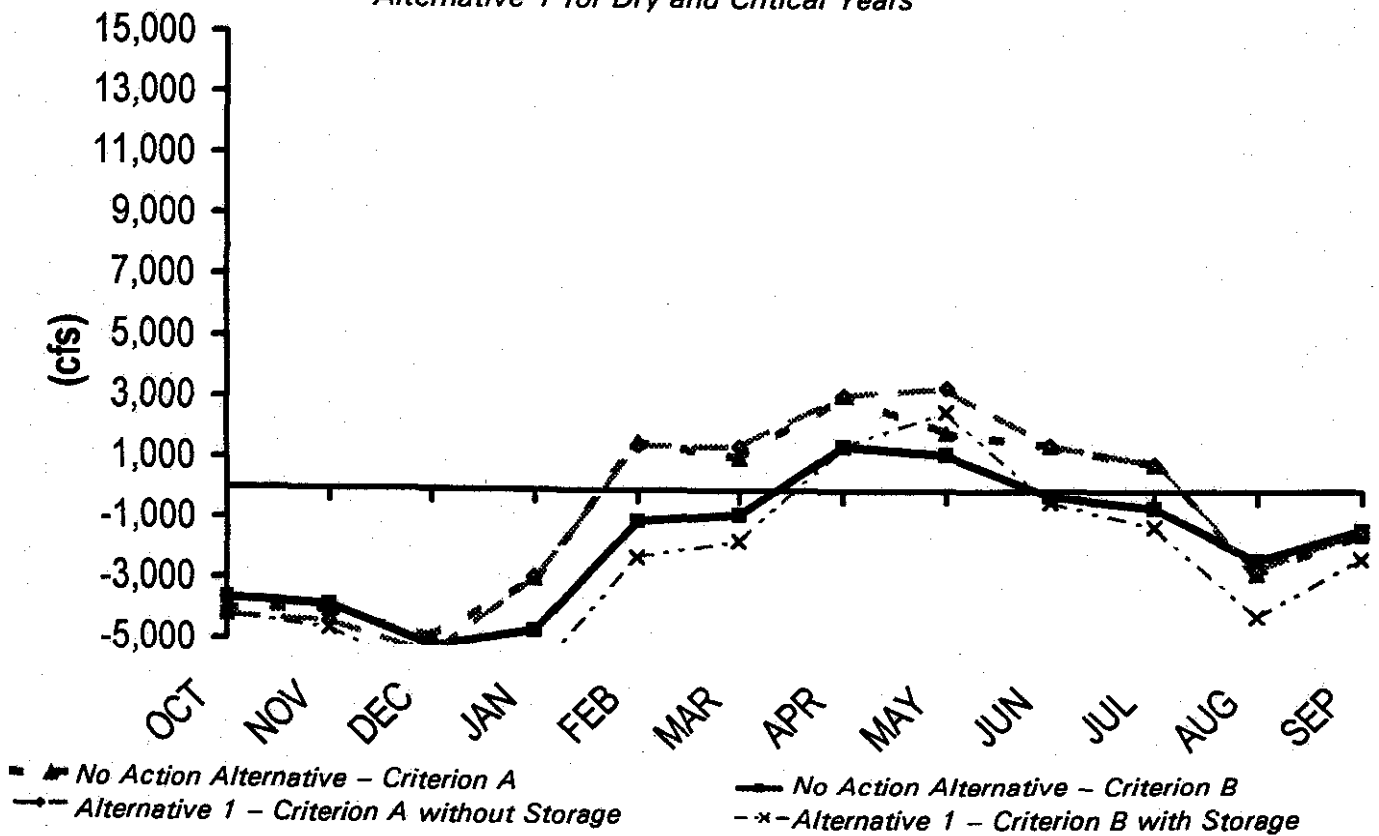


Figure 5.2-20. Average Monthly Cross-Delta Flow under Alternative 1 for the Long-Term Period

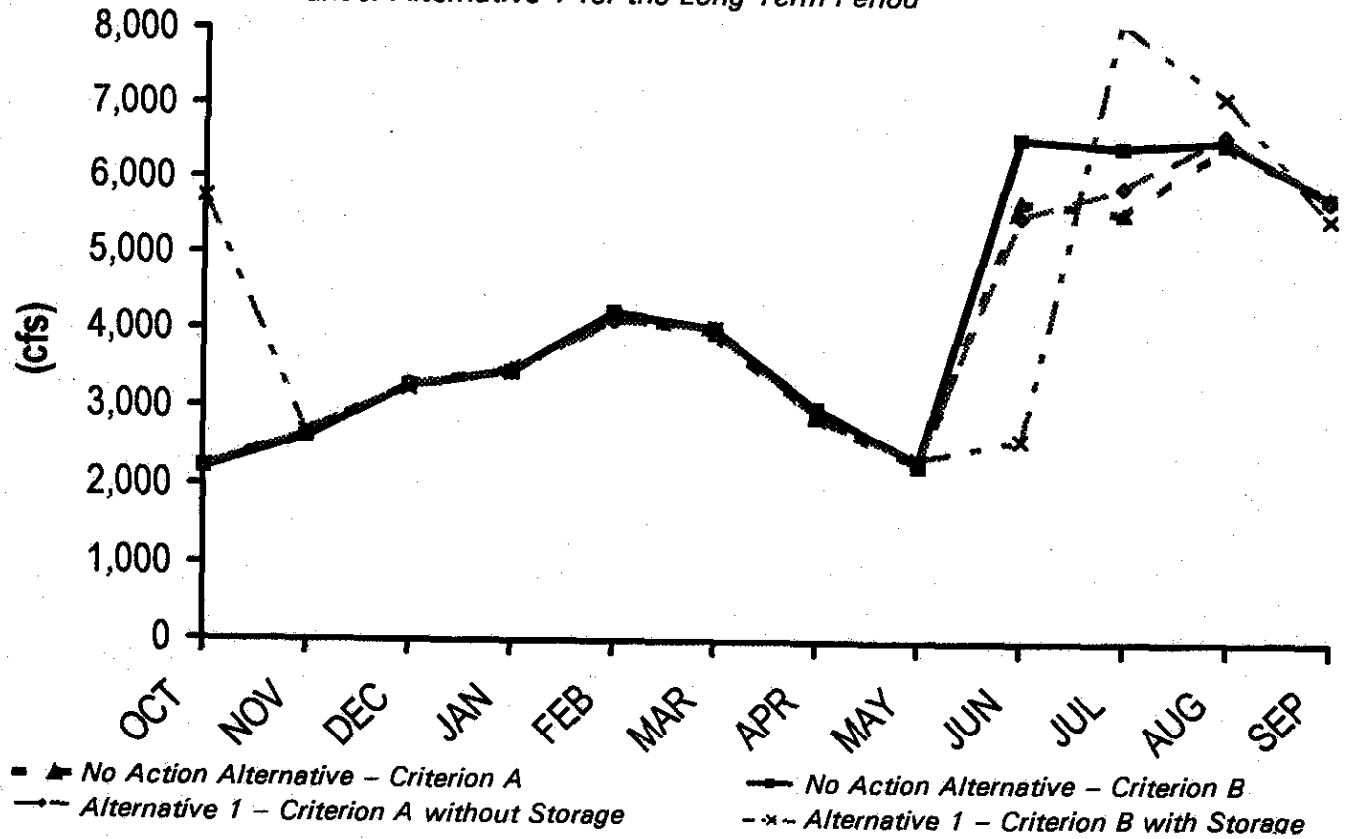
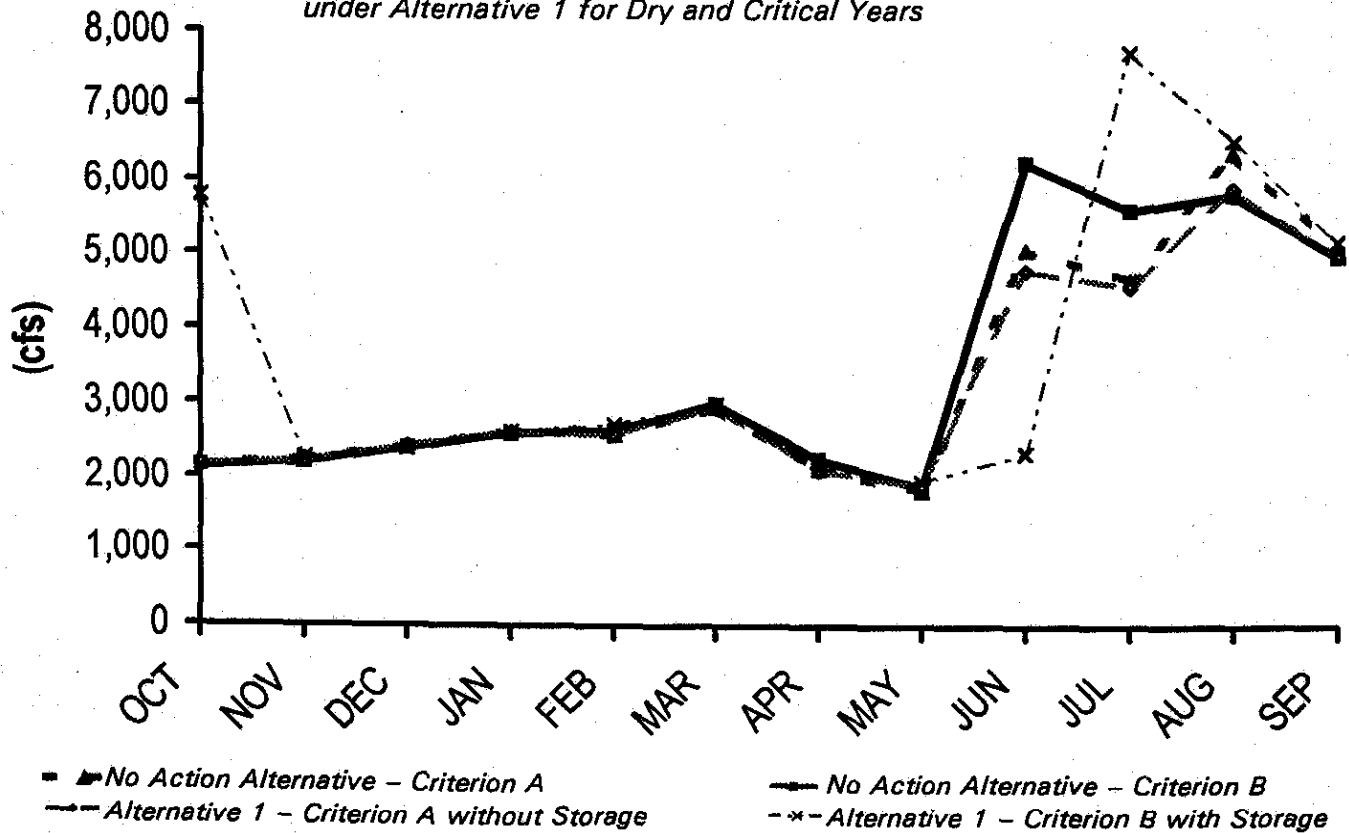


Figure 5.2-21. Average Monthly Cross-Delta Flow under Alternative 1 for Dry and Critical Years



Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from -1,000 to -1,200 cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from -2,100 to -2,400 cfs.

Average monthly San Joaquin River flow at Antioch ranges from -600 to -1,300 cfs in August over the long-term period under Alternative 1. In dry and critical years under Alternative 1, reverse flow in August may vary by -300 to 400 cfs relative to the No Action Alternative, resulting in flow ranging from -500 to -1,200 cfs. Increases in reverse flow in December range from 60 to 700 cfs under Alternative 1 in dry and critical years, resulting in flow ranging from -2,500 to -3,100 cfs.

Stage

South Delta water levels are highly influenced by Delta inflow, tidal action, diversions and Delta exports. During times of high Delta exports, in combination with tidal effects, water levels in the south Delta drop significantly, making it difficult to operate agricultural diversions. In order to improve the availability of water and flow circulation patterns for agricultural users in the south Delta, flow control structures or functional equivalents may be constructed and operated as part of Alternative 1. Flow control structures may be located along Middle River upstream of Victoria Island and along Old River near Paradise Cut. Both flow control structures are operated over the course of the irrigation season, from April through October, for this evaluation. These two structures would be operated to allow water to pass upstream into the controlled reaches during higher tides and to prevent water levels within the controlled reaches from dropping as the high tides recede. DSM2 simulations indicate that in-Delta flow barriers would be effective in raising south Delta water levels, essentially independent of the selection of an alternative.

Middle River Upstream of Victoria Island. The monthly average minimum stage in Middle River was evaluated for the No Action Alternative and Alternative 1 for the long-term period and dry and critical years.

Over the long-term period under the No Action Alternative, the highest minimum stage in Middle River typically occurs in February and March and is about 0.1 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl.

In the absence of new surface storage, Alternative 1 increases water levels by an average of 2.1 feet during the operation period, resulting in water surface elevations ranging from 1.3 to 2.0 feet above msl. Similar water levels result by implementing new surface storage under Alternative 1 during the period of operation. During dry and critical years under the No Action Alternative, the highest minimum stage in Middle River typically occurs in April and is about 0.5 foot below msl. The lowest minimum stage typically occurs in September and is about 0.7 foot below msl.

Alternative 1 stage improvements for dry and critical years are similar to those described for the long-term period, and resulting water levels range from 1.3 to 1.7 feet above msl.

During times of high Delta exports, in combination with tidal effects, water levels in the south Delta drop significantly, making it difficult to operate agricultural diversions.

With or without new surface storage, Alternative 1 would increase water levels at Middle River.



Old River Flow at Bacon Island. The monthly average minimum stage in Old River was evaluated for the No Action Alternative and Alternative 1 for the long-term period and dry and critical years. Flow control structures under Alternative 1 are operated from April through October for all hydrologic periods. Over the long-term period under the No Action Alternative, the highest minimum stage in Old River typically occurs in February and March and is about 0.6 foot above msl. The lowest minimum stage typically occurs in August and is about 0.7 foot below msl.

In the absence of new surface storage, Alternative 1 increases water levels by an average of 2.1 feet from June through September, resulting in water surface elevations ranging from 1.5 to 1.9 feet above msl. In November under Alternative 1, monthly average minimum stage decreases by up to 0.4 foot, resulting in water surface elevations as low as 0.8 foot below msl.

During dry and critical years under the No Action Alternative, the highest minimum stage in Old River typically occurs in April and is about 0.3 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl.

Alternative 1 stage improvements for dry and critical years are similar to those described for the long-term period and resulting water levels range from 1.4 to 1.6 feet above msl. Water level decreases in November for dry and critical years are similar to those experienced for the long-term period and resulting water surface elevations are as low as 1.0 foot below msl.

Mass Fate

The DSM2 model was used to perform several mass tracking simulations for Alternative 1. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

During dry and critical years under the No Action Alternative, the highest minimum stage in Old River typically occurs in April at about 0.3 foot below msl and the lowest minimum stage typically occurs in August at about 0.8 foot below msl.

Bay Region

Bay-Delta X2 position was evaluated for the No Action Alternative and Alternative 1 for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Alternative 1 increases average monthly X2 position by about 0.6 km in September. Alternative 1 could increase X2 position by about 0.2 km or decrease X2 position by about 0.3 km in March. During dry and critical years under the No Action Alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and

Alternative 1 could increase X2 position by about 0.2 km or decrease X2 position by about 0.3 km in March.



Figure 5.2-22. Average Monthly X2 Position under Alternative 1 for the Long-Term Period

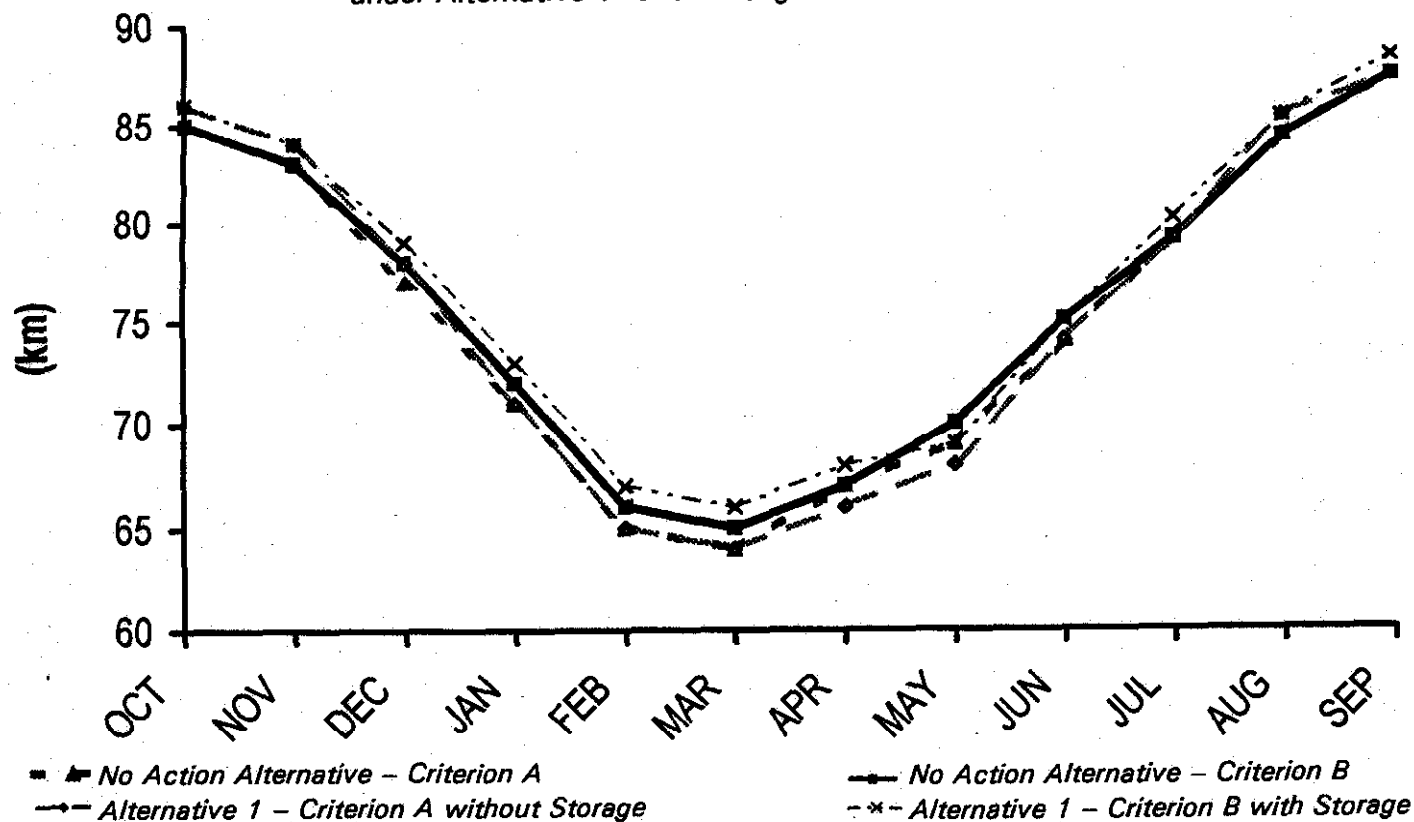
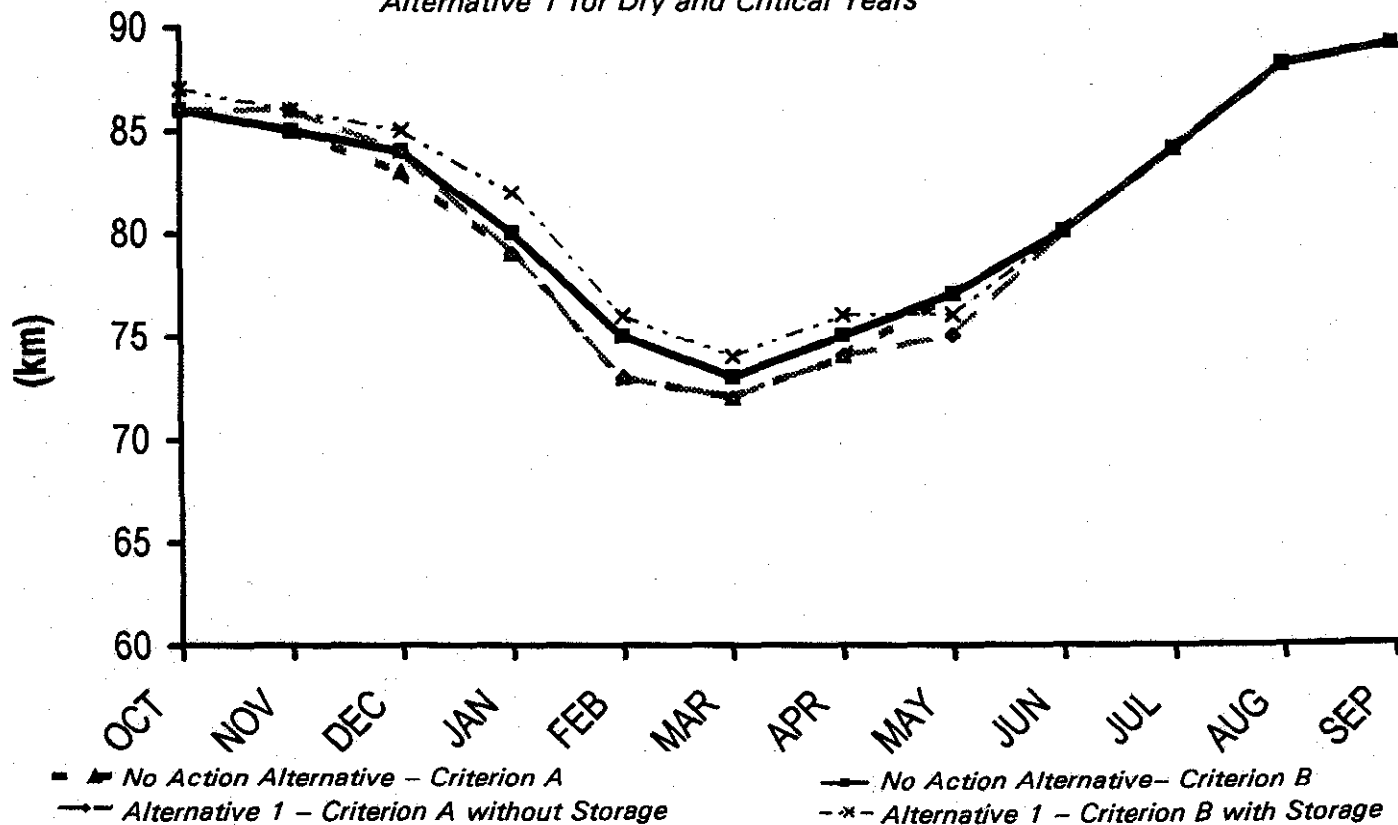


Figure 5.2-23. Average Monthly X2 Position under Alternative 1 for Dry and Critical Years



However, X2 position may increase by 0.3 km or decrease by 0.4 km in March. Figures 5.2-22 and 5.2-23 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between Alternative 1 and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under Alternative 1. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an in-stream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B under the modeling analysis.

River Flows. Average monthly flow in the Sacramento River at Freeport was evaluated for Alternative 1 and the No Action Alternative. Figures 5.2-24 and 5.2-25 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

In the absence of new storage facilities, Alternative 1 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer under all hydrologic conditions. Alternative 1 increases average monthly flow by as much as 1,400 cfs during summer. Even with new storage facilities, Alternative 1 has little impact on average monthly flow in most months. Anticipated flow increases are most pronounced during summers of dry and critical years—up to 900 cfs in July.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for Alternative 1 and the No Action Alternative. Figures 5.2-26 and 5.2-27 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under Alternative 1, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring. Alternative 1 increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. Similarly, in dry and critical years, Alternative 1 increases average monthly flow in spring by as much as 1,300 cfs.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer under the No Action Alternative as well as under Alternative 1. This pattern is consistent for the long-term period and for dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs. Under Alternative 1, the lowest long-term period summer releases are generally associated with the Criterion B water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated

With or without new storage, Alternative 1 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative.

Under Alternative 1, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring.



Figure 5.2-24. Average Monthly Sacramento River Flow at Freeport under Alternative 1 for the Long-Term Period

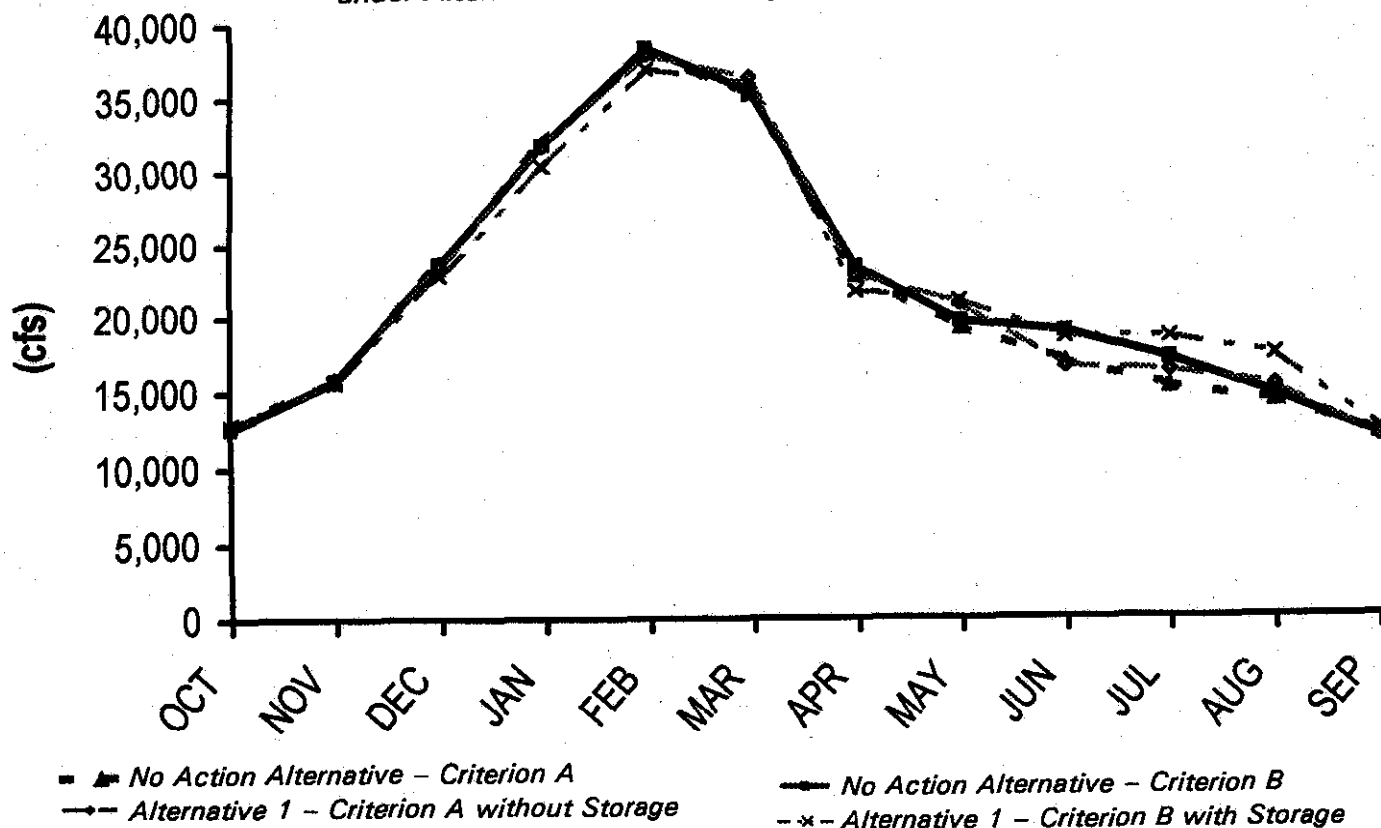


Figure 5.2-25. Average Monthly Sacramento River Flow at Freeport under Alternative 1 for Dry and Critical Years

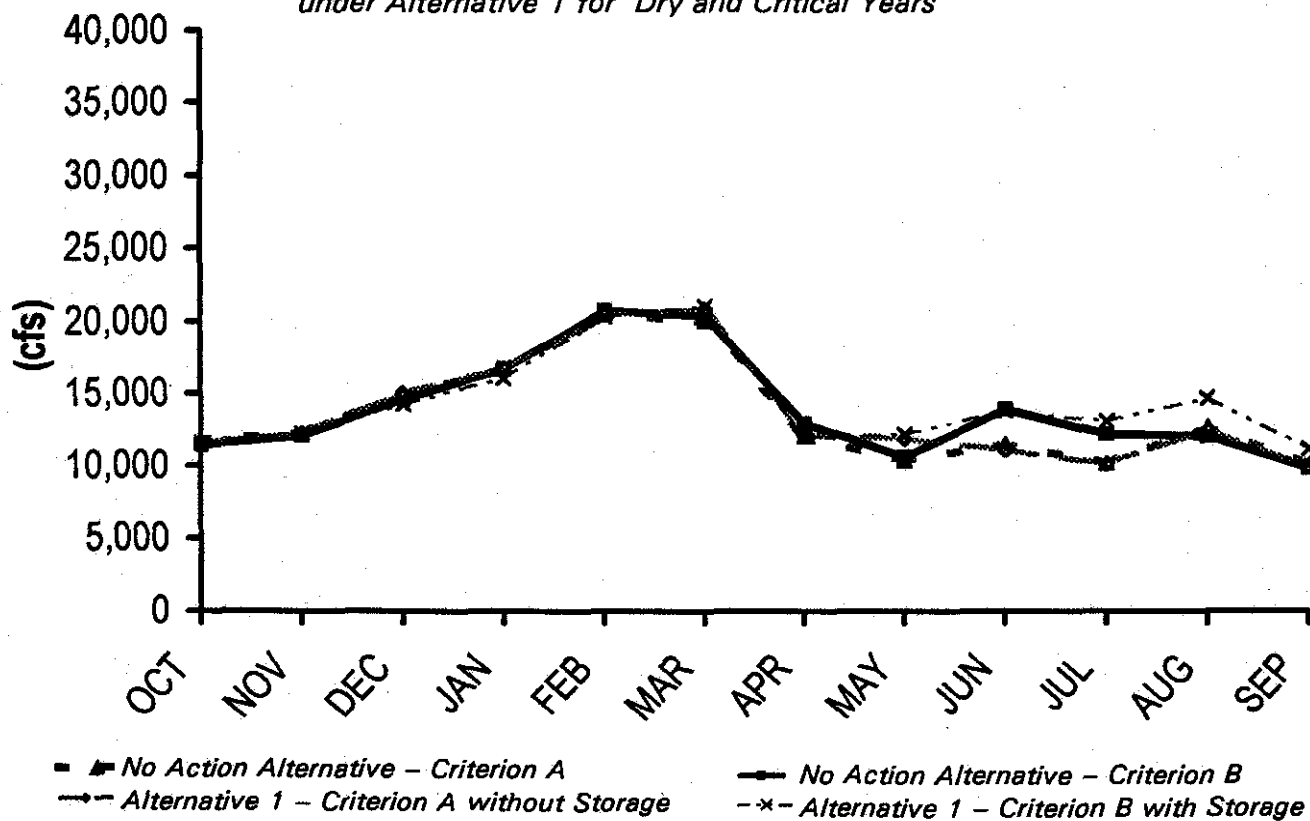


Figure 5.2-26. Average Monthly San Joaquin River Flow at Vernalis under Alternative 1 for the Long-Term Period

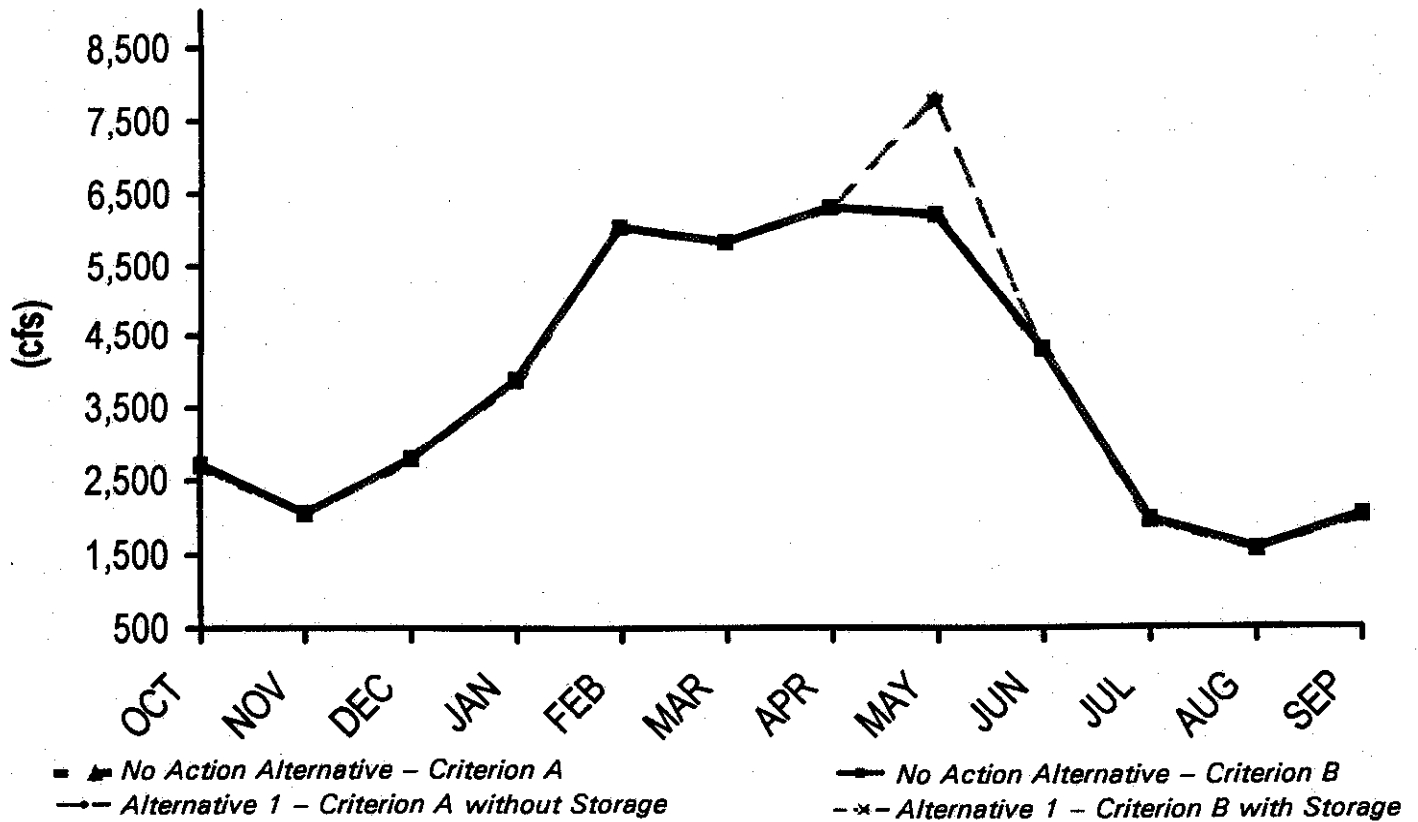
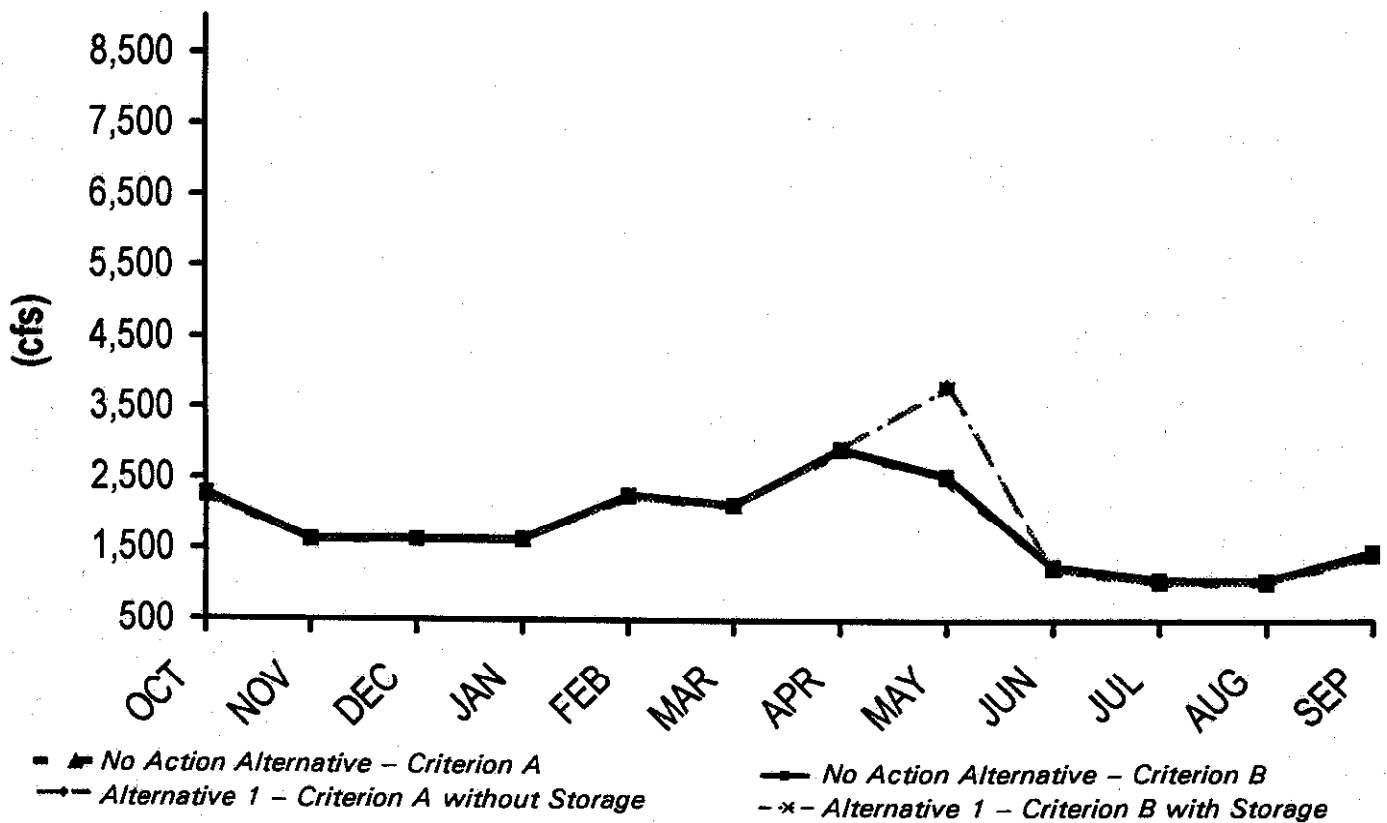


Figure 5.2-27. Average Monthly San Joaquin River Flow at Vernalis under Alternative 1 for Dry and Critical Years



with the Criterion B water management assumptions in the absence of additional storage capacity.

New storage would provide increased operational flexibility and would supplement releases from existing facilities. If no new storage is implemented under Alternative 1, summer releases from existing facilities may increase up to 1,300 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 1, summer releases may decrease as much as 1,400 cfs or increase up to 600 cfs relative to the No Action Alternative. During winter, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in Alternative 1, necessitates increased flood control releases in winter.

Average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative by implementation of Alternative 1. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.

New Reservoir Diversions and Releases. Figures 5.2-28 and 5.2-29 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under Alternative 1. Under Alternative 1, new surface storage diversions typically occur during winter and spring, with peak diversions in late winter. Over the long-term period, the range of peak average monthly diversions is 1,400-2,300 cfs. For dry and critical years, the range of peak average monthly diversions is 200-1,400 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer when the greatest environmental benefits are anticipated, with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. Environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Under Alternative 1, maximum average monthly releases in dry and critical years are on the order of 1,200 cfs, while maximum average monthly releases are approximately 900 cfs for the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Peak average monthly releases range from 700 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,100 to over 2,100 cfs.

New San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Maximum diversions during dry and critical years occur in early summer (140 cfs), while average monthly diversions over the long-term period are greatest in late winter (170 cfs).

If no new storage is implemented under Alternative 1, summer releases from existing facilities may increase up to 900 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 1, summer releases may decrease as much as 400 cfs or increase up to 2,600 cfs relative to the No Action Alternative.

New surface storage diversions in the Sacramento River Region typically occur during winter and spring, with peak diversions in late winter.

No variation in releases is evident between the water management scenarios under Alternative 1 for the San Joaquin River Region.



Figure 5.2-28. New Surface Storage Diversions in the Sacramento River Region under Alternative 1 for the Long-Term Period

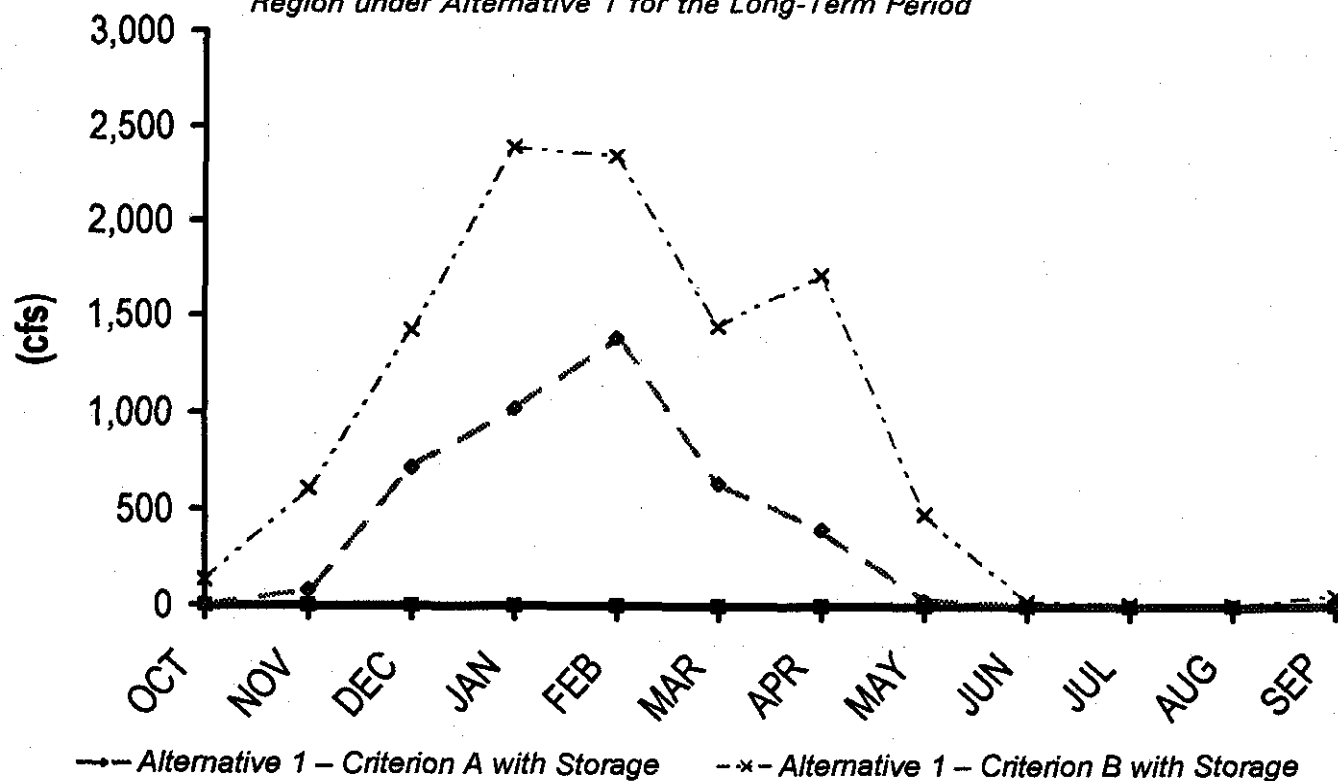
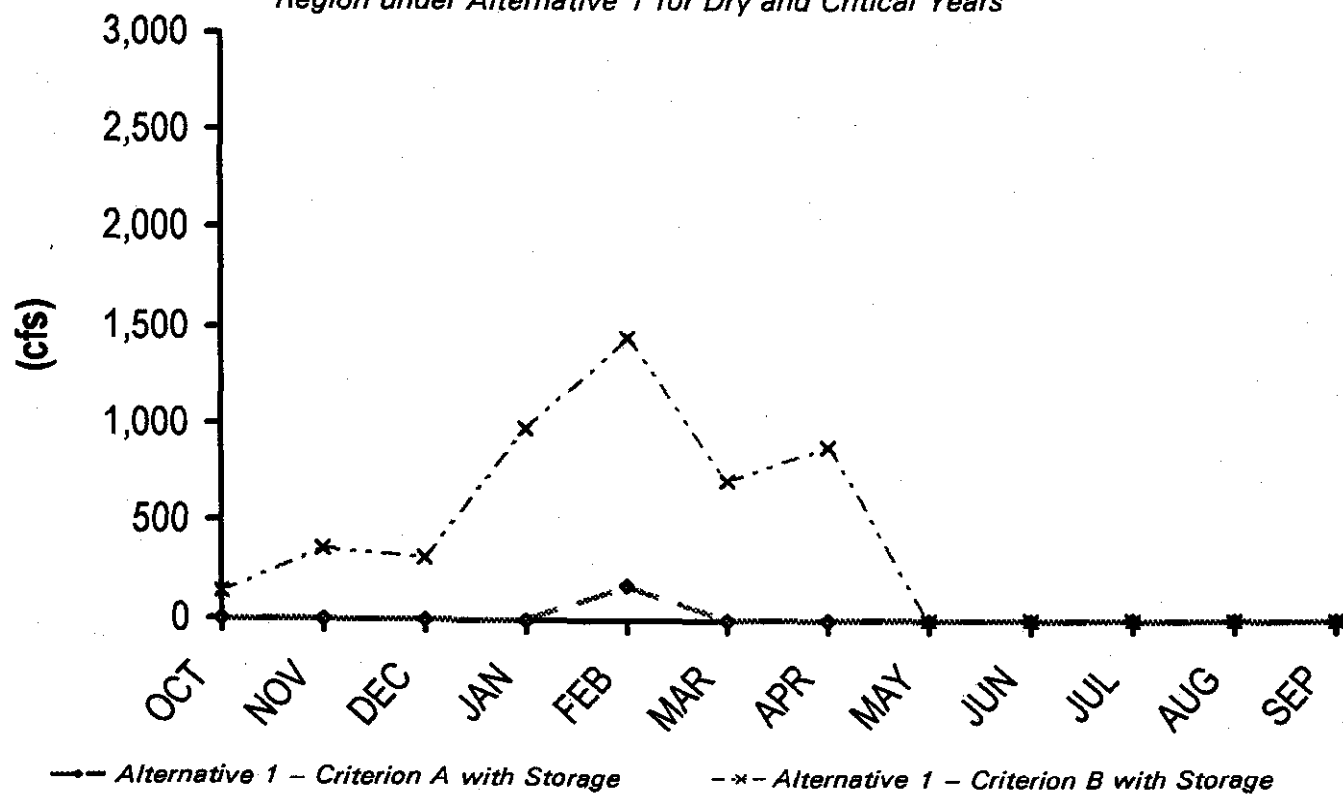


Figure 5.2-29. New Surface Storage Diversions in the Sacramento River Region under Alternative 1 for Dry and Critical Years



Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under Alternative 1. Maximum average monthly releases range from 550 to 560 cfs for the long-term period and from 340 to 350 cfs for dry and critical years.

5.2.8.2 ALTERNATIVE 2

Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross Delta, Old River at Bacon Island, and San Joaquin River at Antioch), water levels (stage), and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, this analysis focuses on a few key locations. Channel flows are described at five locations, and stage is described at two locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs.

Alternative 2 decreases flow by as much as 8,500 cfs in February and by as much as 2,600 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occurs in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, Alternative 2 decreases flow in February by as much as 7,000 cfs. In September, Alternative 2 modifies flow by -1,300 to 300 cfs. Figures 5.2-30 and 5.2-31 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

QWEST Flow. QWEST flow was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about -4,000 to -4,300 cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400 to 3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from -4,900 to -5,200 cfs.

Alternative 2 decreases flow by as much as 8,500 cfs in February and by as much as 2,600 cfs in September.

Alternative 2 increases average monthly positive QWEST flow over the long-term period in April by as much as 1,300 cfs and decreases average monthly reverse QWEST flow in October by as much as 4,700 cfs.



Figure 5.2-30. Average Monthly Sacramento River Flow at Rio Vista under Alternative 2 for the Long-Term Period

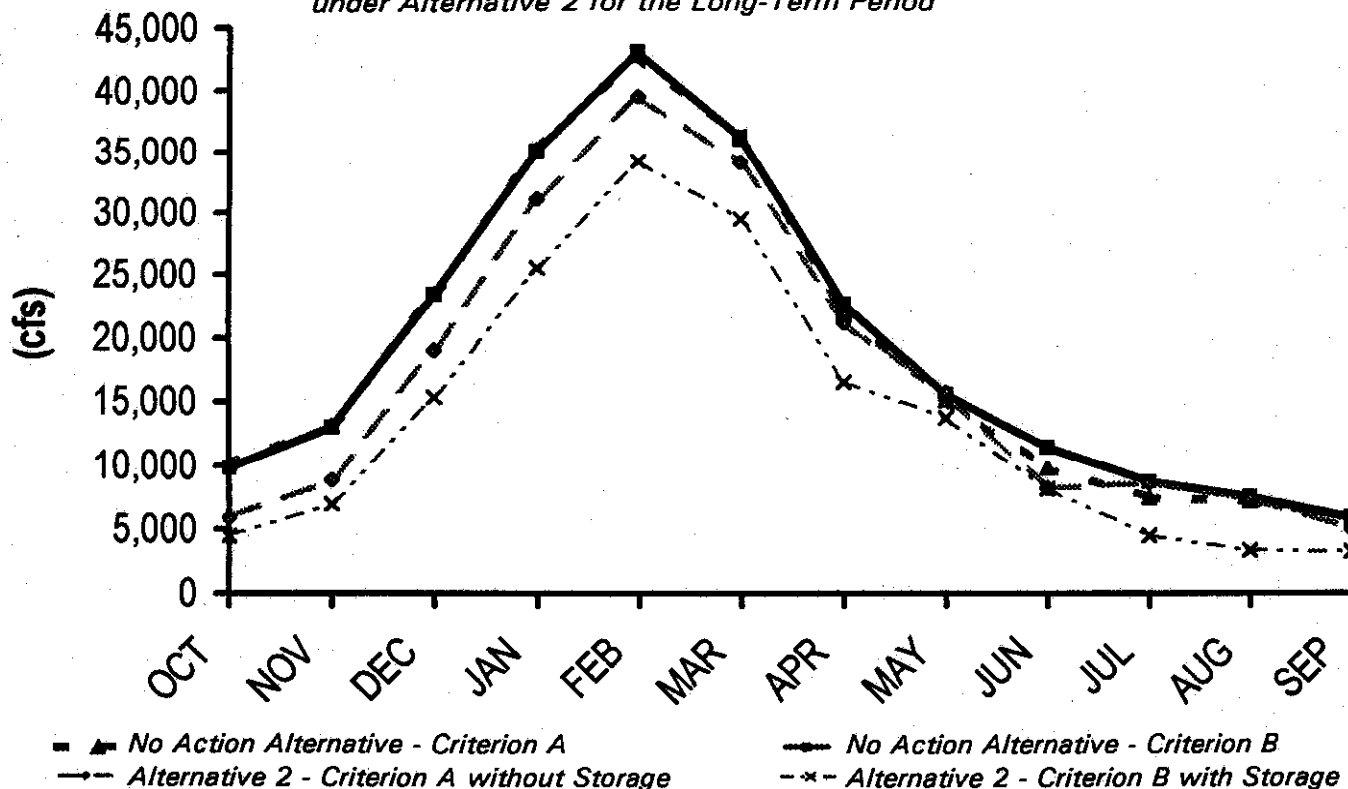
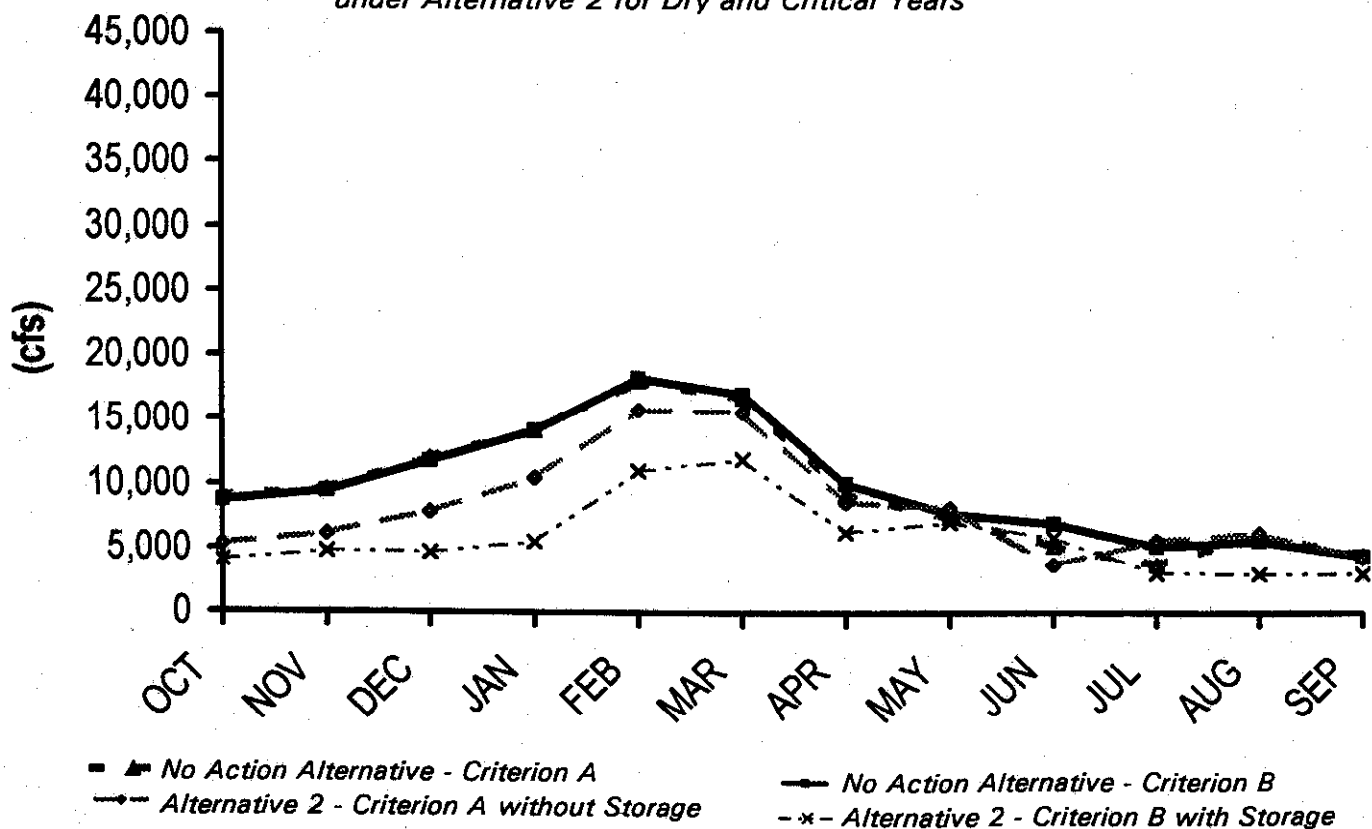


Figure 5.2-31. Average Monthly Sacramento River Flow at Rio Vista under Alternative 2 for Dry and Critical Years



Alternative 2 increases average monthly positive QWEST flow over the long-term period in April by as much as 1,300 cfs and decreases average monthly reverse QWEST flow in October by as much as 4,700 cfs. During dry and critical years, Alternative 2 increases average monthly positive QWEST flow in April by as much as 1,300 cfs and decreases average monthly reverse QWEST flow in December by as much as 5,600 cfs. Figures 5.2-32 and 5.2-33 compare average monthly QWEST flow for the long-term period and for dry and critical years, respectively.

Cross-Delta Flow. Cross-Delta flow was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Differences in cross-Delta flow are best summarized by flows occurring in August, December, and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December, and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, and averages 2,400 cfs in December and 1,800 cfs in May.

Under Alternative 2, over the long-term period and in dry and critical years, cross-Delta flow may increase or decrease in August, whereas cross-Delta flow in December and May typically increases. Over the long-term period under Alternative 2, cross-Delta flow in August may vary by -150 to 3,800 cfs relative to the No Action Alternative. Increases in cross-Delta flows over the long-term period range from 4,000 to 6,400 cfs in December and from 600 to 2,400 cfs in May. During dry and critical years under Alternative 2, cross-Delta flow in August may vary by -300 cfs to 3,000 cfs relative to the No Action Alternative. Increases in cross-Delta flow during dry and critical years range from 3,800 to 5,900 cfs in December and from 500 to 1,700 cfs in May. Figures 5.2-34 and 5.2-35 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about -3,400 cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from -3,000 to -3,600 cfs.

Over the long-term period under Alternative 2, increases in reverse flow in Old River at Bacon Island in August range from 700 to 1,600 cfs, resulting in flow ranging from -4,100 to -5,000 cfs. In dry and critical years under Alternative 2, increases in reverse flow in August range from 30 to 900 cfs, resulting in flow ranging from -3,600 to -4,400 cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for Alternative 2 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from -1,000 to -1,200 cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from -2,100 to -2,400 cfs.

Under Alternative 2, over the long-term period and in dry and critical years, cross-Delta flow may increase or decrease in August, whereas cross-Delta flow in December and May typically increases.

Over the long-term period under Alternative 2, increases in reverse flow in Old River at Bacon Island in August range from 700 to 1,600 cfs. In dry and critical years, Alternative 2, increases in reverse flow in August range from 30 to 900 cfs.



Figure 5.2-32. Average Monthly QWEST Flow under Alternative 2 for the Long-Term Period

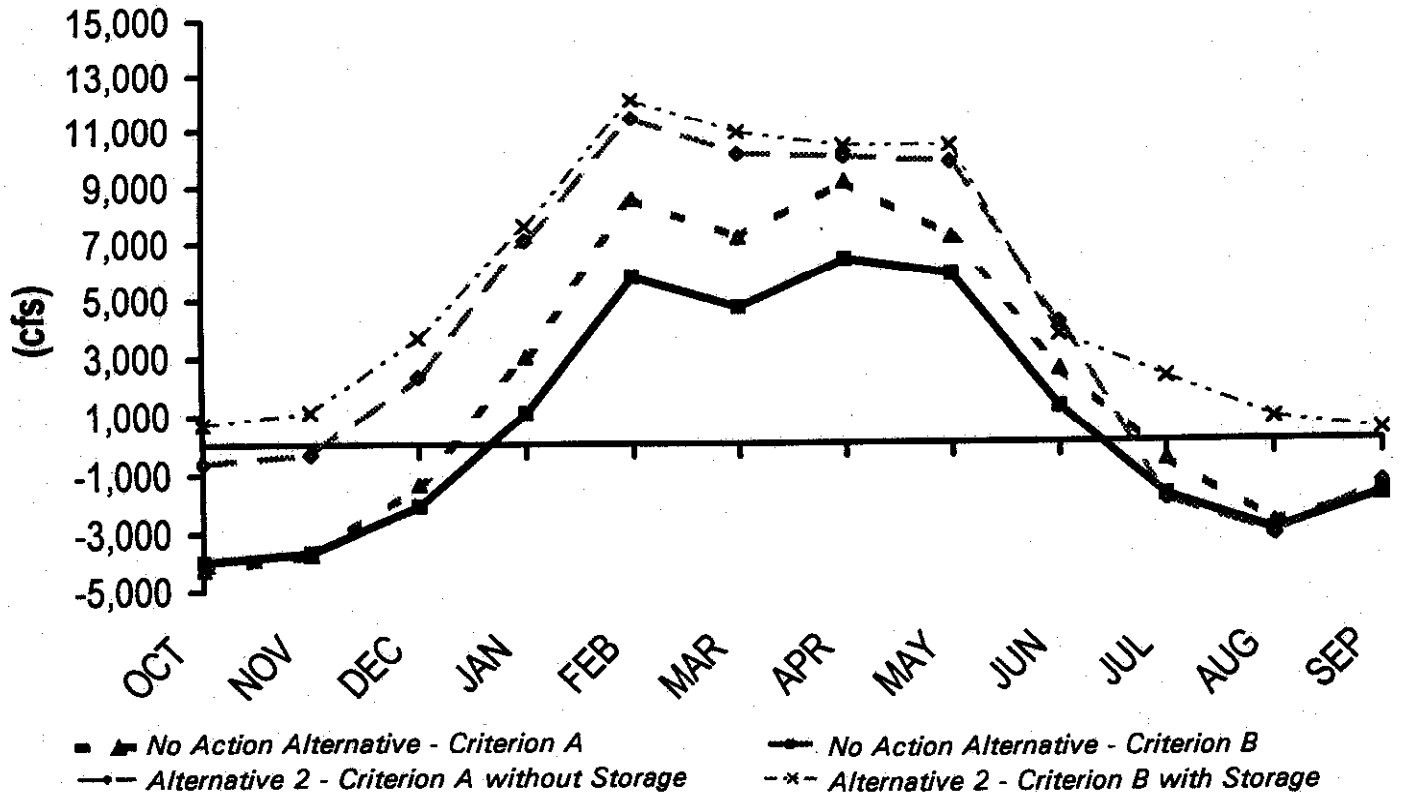


Figure 5.2-33. Average Monthly QWEST Flow under Alternative 2 for Dry and Critical Years

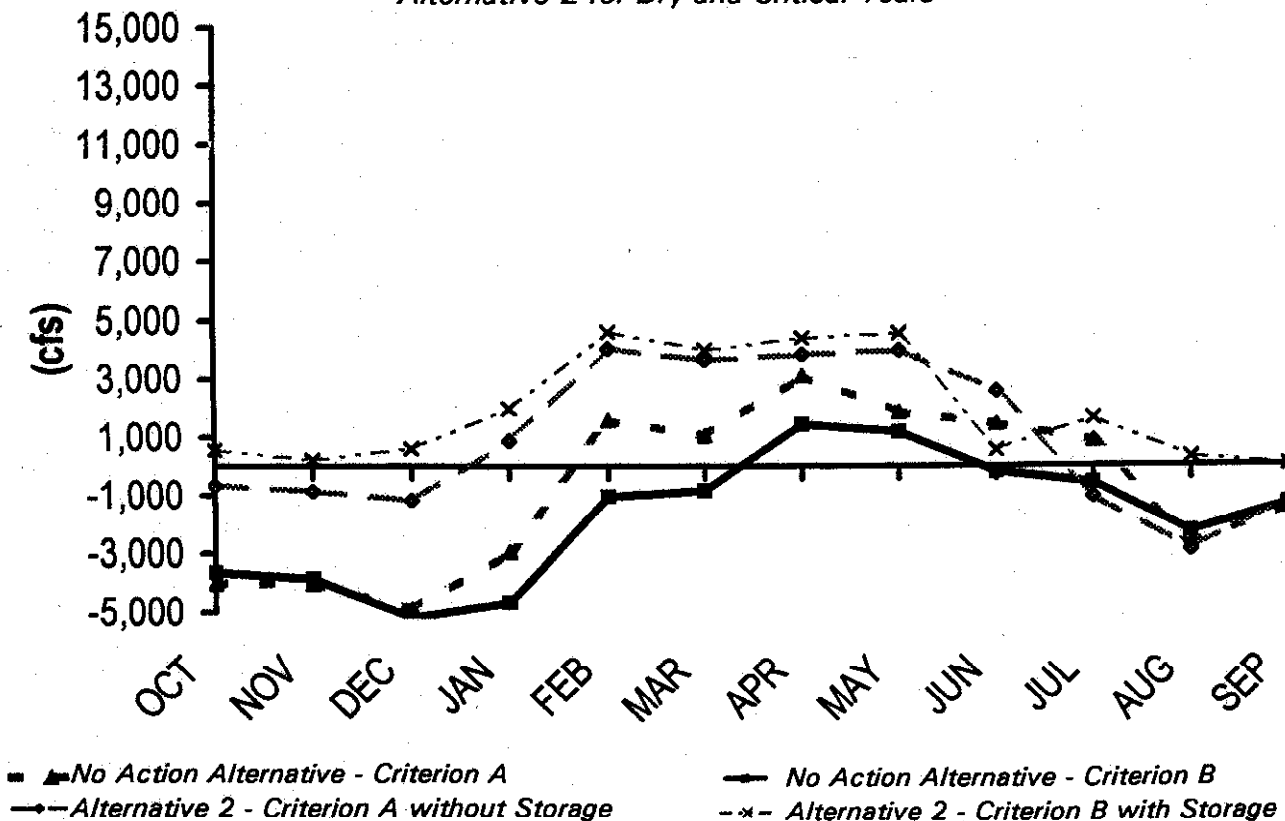


Figure 5.2-34. Average Monthly Cross-Delta Flow under Alternative 2 for the Long-Term Period

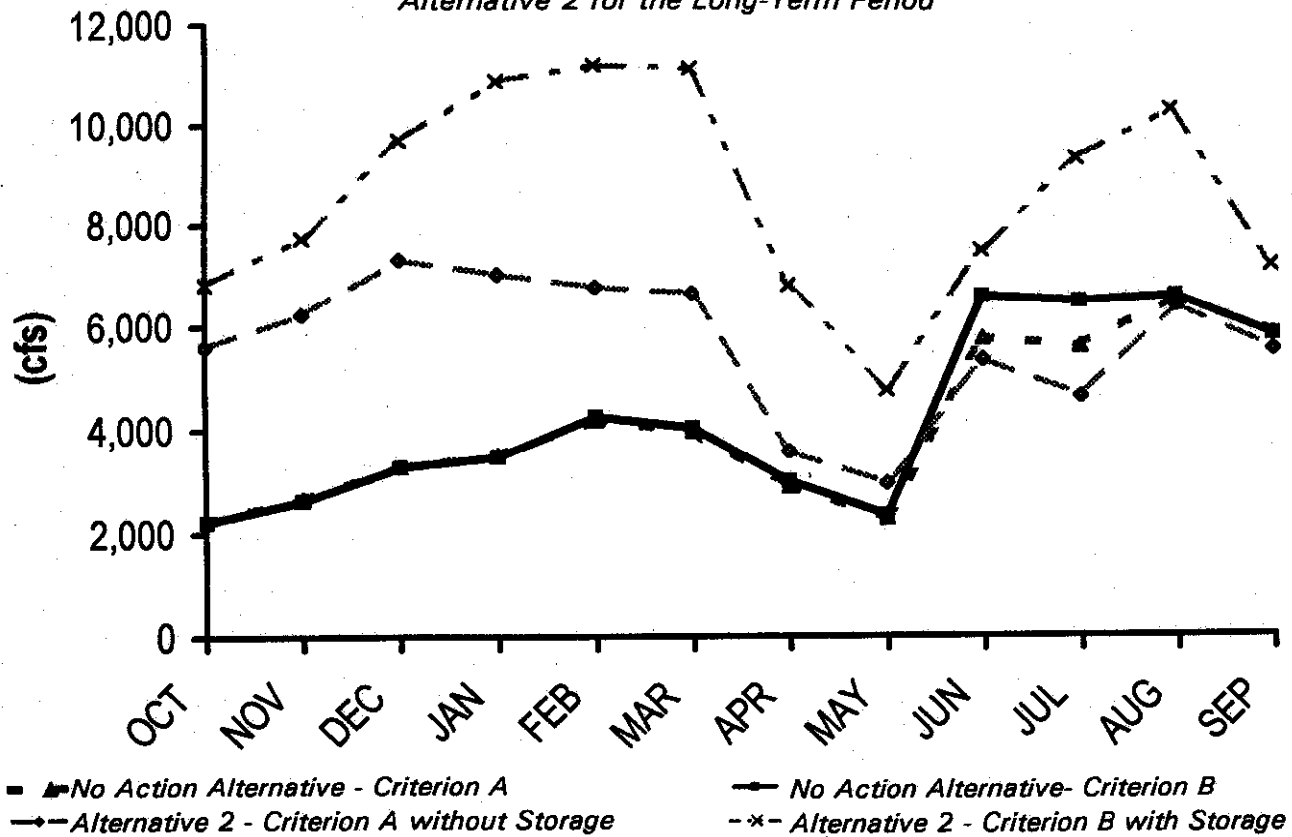
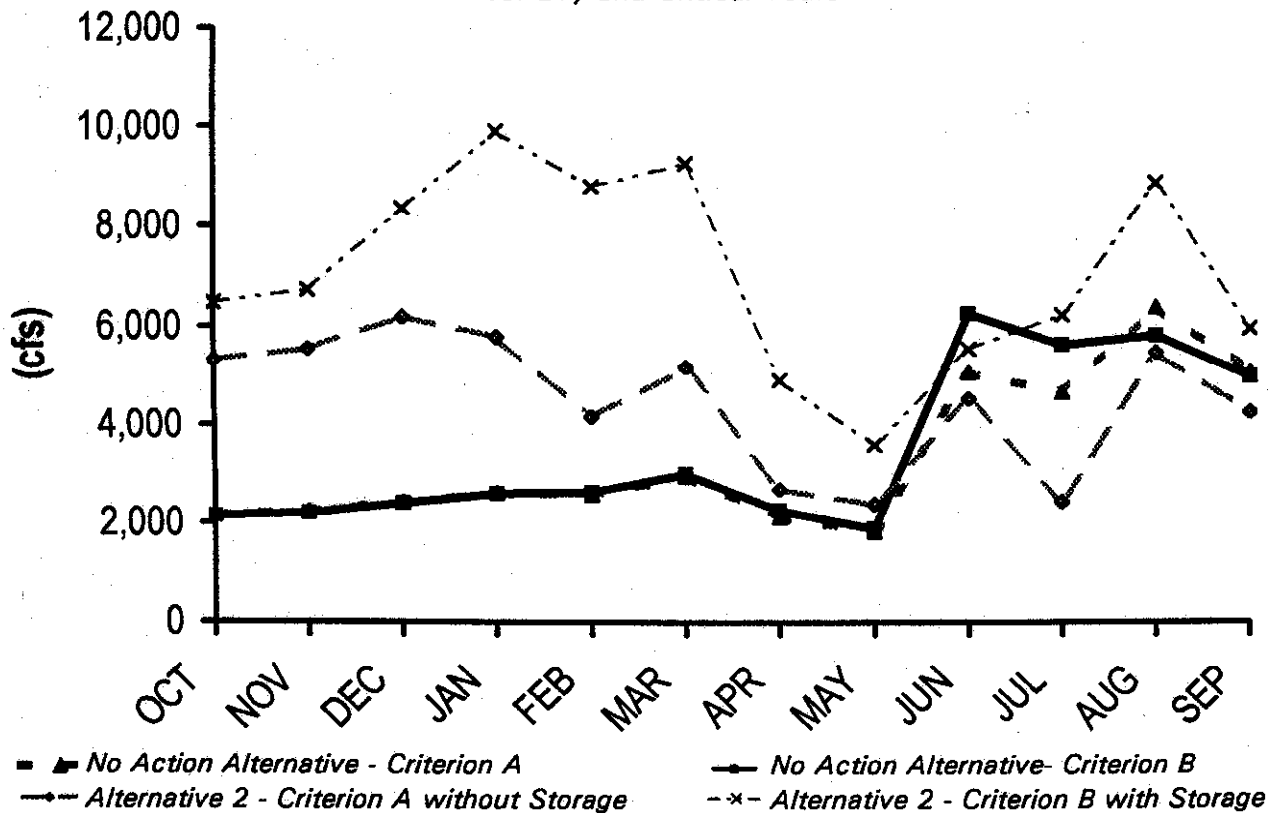


Figure 5.2-35. Average Monthly Cross-Delta Flow under Alternative 2 for Dry and Critical Years



Average monthly San Joaquin River flow at Antioch ranges from -900 to 500 cfs in August over the long-term period under Alternative 2. In dry and critical years under Alternative 2, reverse flow in August may vary by -500 to 200 cfs relative to the No Action Alternative, resulting in flow ranging from -1,000 to 200 cfs. Decreases in reverse flow in December range from 2,500 to 3,400 cfs under Alternative 2 in dry and critical years, resulting in flow ranging from 500 to 1,400 cfs.

Stage

Middle River Upstream of Victoria Island. The monthly average minimum stage in Middle River was evaluated for the No Action Alternative and Alternative 2 for the long-term period and dry and critical years. Flow control structures in Middle River under Alternative 2 (same as described above for Alternative 1) are operated from April through October for all hydrologic periods for this evaluation. Over the long-term period under the No Action Alternative, the highest minimum stage in Middle River typically occurs in February and March, and is about 0.1 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl.

In the absence of new surface storage, Alternative 2 increases water levels by an average of 2.1 feet during the operation period, resulting in water surface elevations ranging from 1.2 to 2.0 feet above msl. Similar water levels result by implementing new surface storage under Alternative 2 during the period of operation. During dry and critical years under the No Action Alternative, the highest minimum stage in Middle River typically occurs in April and is about 0.5 foot below msl. The lowest minimum stage typically occurs in September and is about 0.7 foot below msl. Alternative 2 stage improvements for dry and critical years are similar to those described for the long-term period and resulting water levels range from 1.3 to 1.7 feet above msl.

With or without new storage, Alternative 2 increases water levels by an average of 2.1 feet during the operation period.

Old River Flow at Bacon Island. The monthly average minimum stage in Old River was evaluated for the No Action Alternative and Alternative 2 for the long-term period and dry and critical years. Flow control structures in Old River under Alternative 2 are operated from April through October for all hydrologic periods. Over the long-term period under the No Action Alternative, the highest minimum stage in Old River typically occurs in February and March, and is about 0.6 foot above msl. The lowest minimum stage typically occurs in August and is about 0.7 foot below msl.

Flow control structures in Old River under Alternative 2 are operated from April through October for all hydrologic periods.

In the absence of new surface storage, Alternative 2 increases water levels by an average of 2.0 feet from June through September, resulting in water surface elevations ranging from 1.4 to 1.9 feet above msl. In November under Alternative 2, monthly average minimum stage decreases by up to 0.2 foot, resulting in water surface elevations as low as 0.6 foot below msl. During dry and critical years under the No Action Alternative, the highest minimum stage in Old River typically occurs in April and is about 0.3 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl. Alternative 2 stage improvements for dry and critical years are similar to those described for the long-term period and resulting water levels range from 1.3 to 1.5 feet above msl. Water level decreases in November for dry and critical years are similar to



those experienced for the long-term period, and resulting water surface elevations are as low as 0.9 foot below msl.

Mass Fate

The DSM2 model was used to perform several mass tracking simulations for Alternative 2. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

Bay Region

Bay-Delta X2 position was evaluated for the No Action Alternative and Alternative 2 for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Alternative 2 increases average monthly X2 position by about 0.6 km in September. Alternative 2 could increase X2 position by about 0.2 km or decrease X2 position by 0.4 km in March.

During dry and critical years under the No Action Alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. During dry and critical years, Alternative 2 decreases average monthly X2 position by about 0.1 km in September. Alternative 2 may increase X2 position by 0.4 km or decrease X2 position by 0.6 km in March. Figures 5.2-36 and 5.2-37 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

Alternative 2 increases average monthly X2 position by about 0.6 km in September. Alternative 2 could increase X2 position by about 0.2 km or decrease X2 position by 0.4 km in March.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between Alternative 2 and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under Alternative 2. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an in-stream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B in the modeling analysis.

River Flows. Average monthly flow in the Sacramento River at Freeport was evaluated for Alternative 2 and the No Action Alternative. Figures 5.2-38 and 5.2-39 compare average



Figure 5.2-36. Average Monthly X2 Position under Alternative 2 for the Long-Term Period

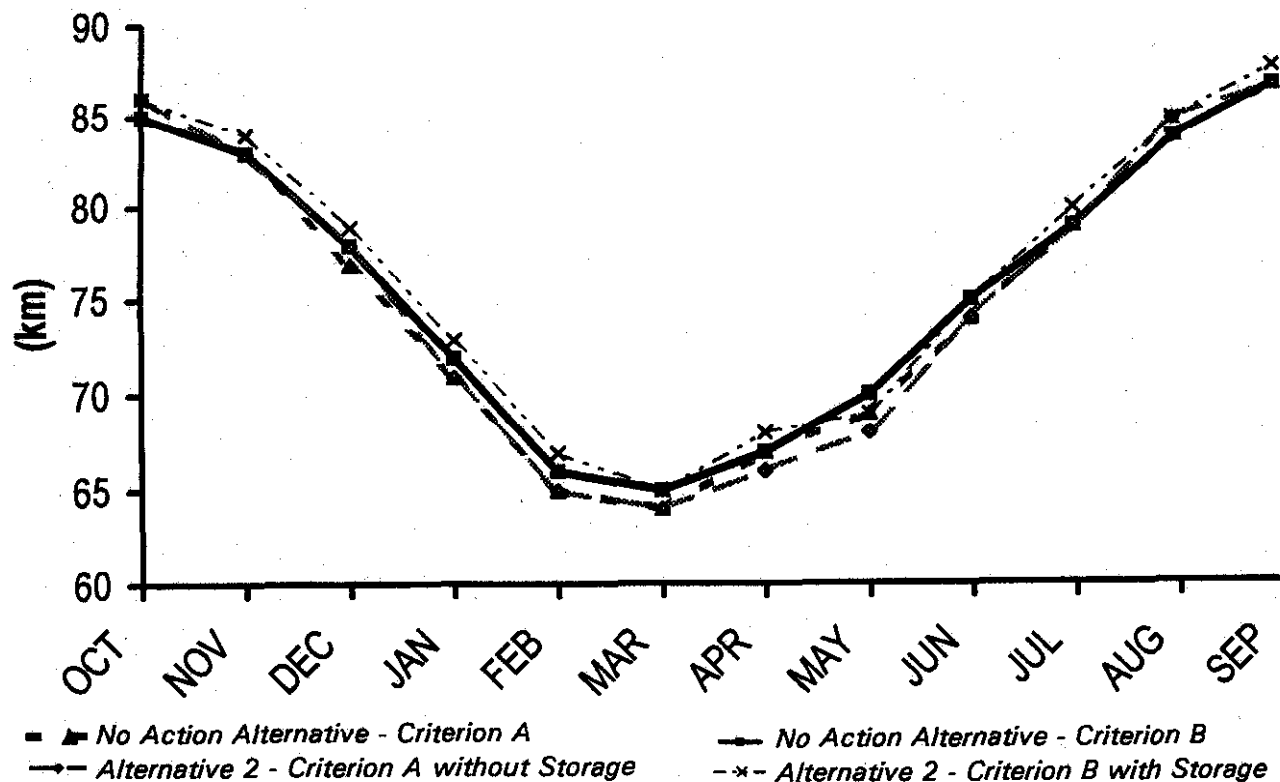


Figure 5.2-37. Average Monthly X2 Position under Alternative 2 for Dry and Critical Years

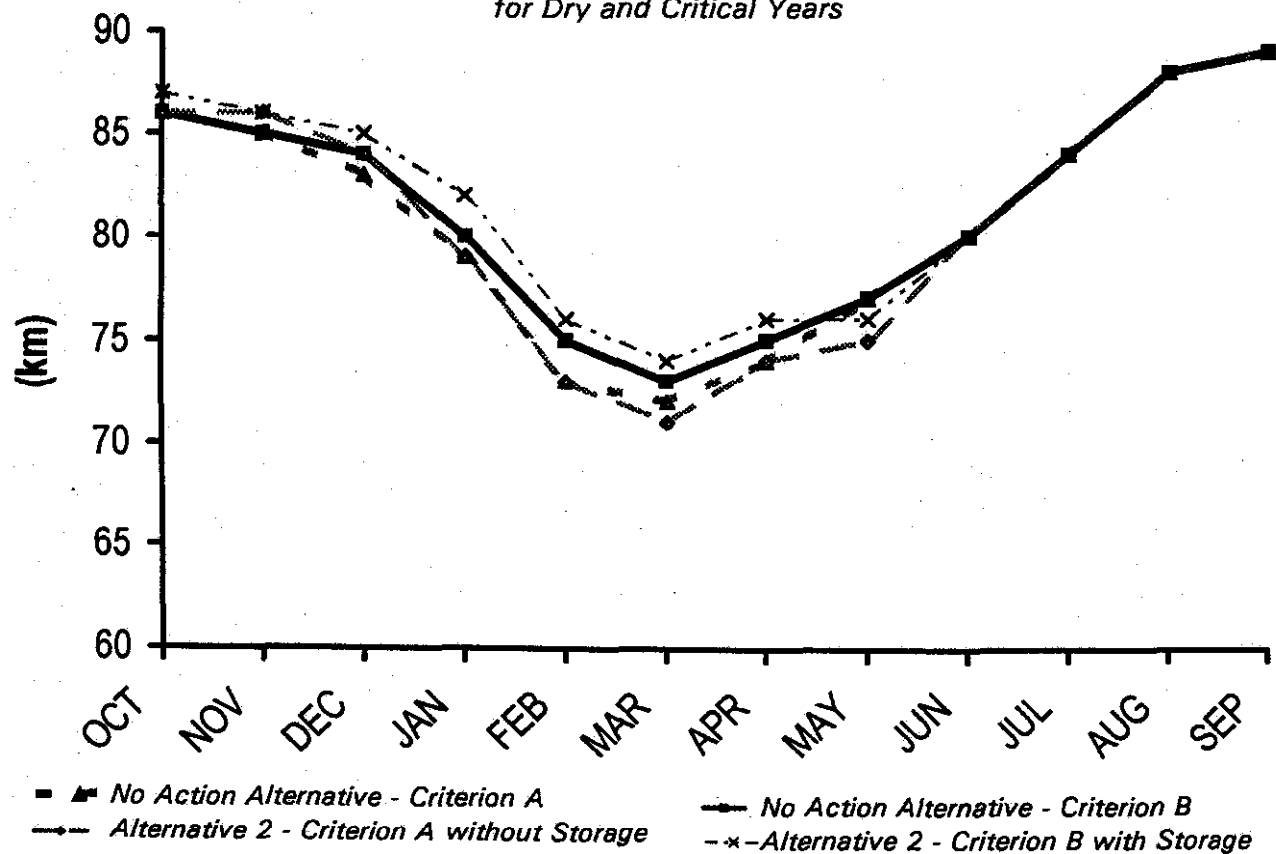


Figure 5.2-38. Average Monthly Sacramento River Flow at Freeport under Alternative 2 for the Long-Term Period

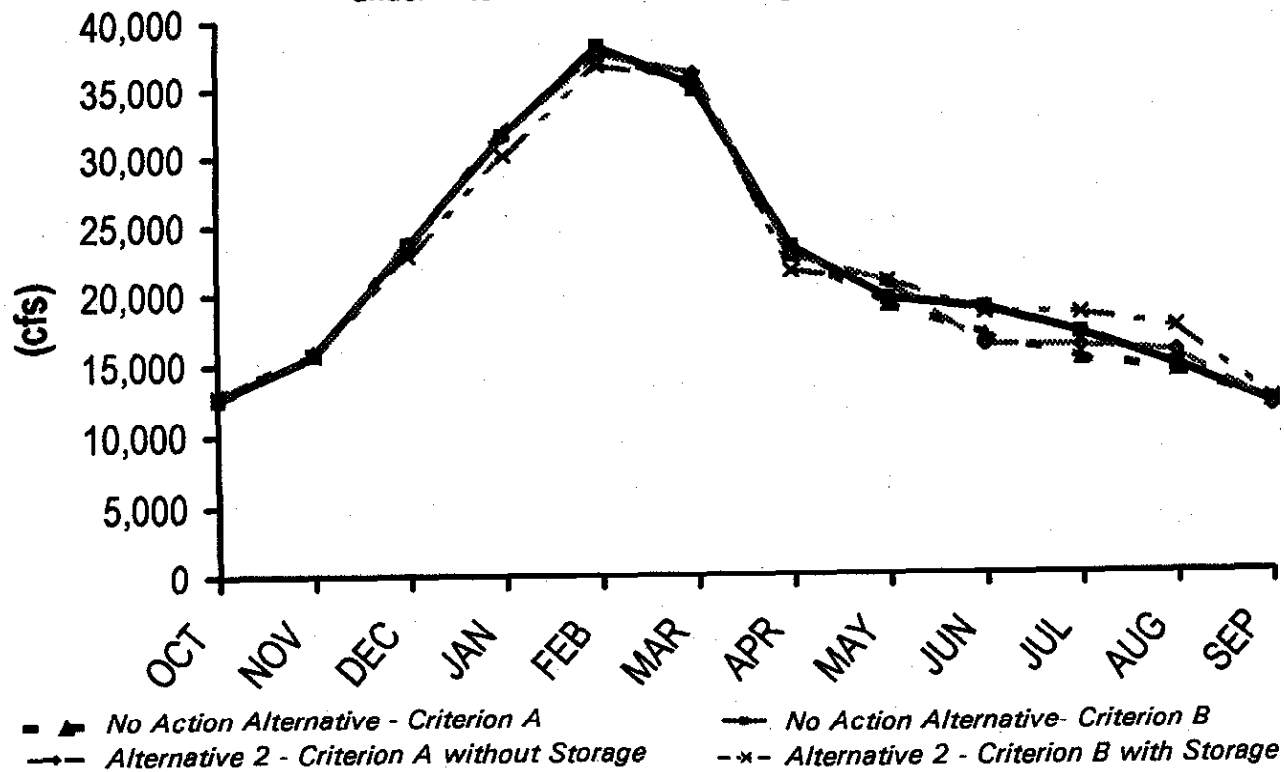
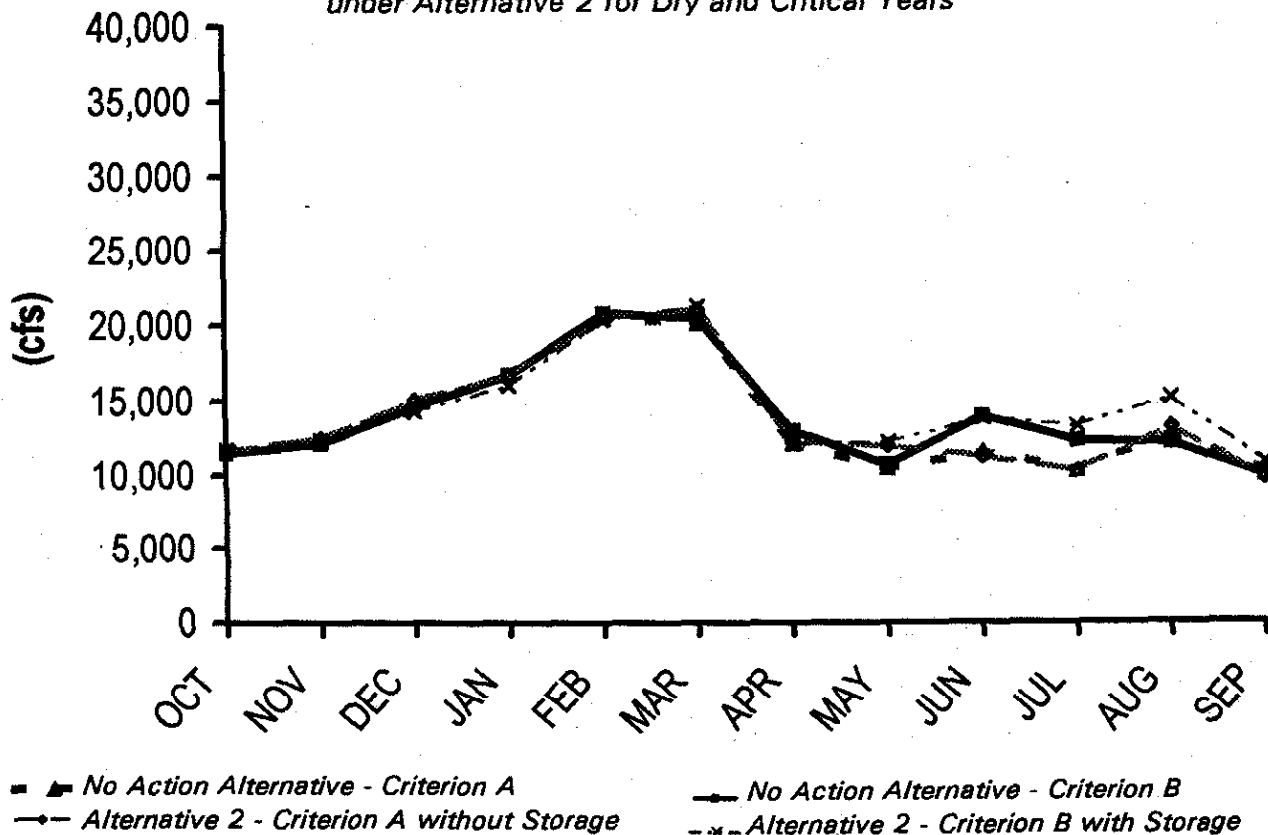


Figure 5.2-39. Average Monthly Sacramento River Flow at Freeport under Alternative 2 for Dry and Critical Years



monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

In the absence of new storage facilities, Alternative 2 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer under all hydrologic conditions. Alternative 2 increases average monthly flow by as much as 1,400 cfs during summer. Even with new storage facilities, Alternative 2 has little impact on average monthly flow in most months. Anticipated flow increases are most pronounced during summers of dry and critical years—up to 1,000 cfs.

Alternative 2 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for Alternative 2 and the No Action Alternative. Figures 5.2-40 and 5.2-41 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under Alternative 2, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except in early spring. Alternative 2 increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. Similarly, in dry and critical years, Alternative 2 increases average monthly flow in spring by as much as 1,400 cfs.

Under Alternative 2, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except in early spring.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer under the No Action Alternative as well as under Alternative 2. This pattern is consistent for the long-term period and dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs. Under Alternative 2, the lowest long-term period summer releases generally are associated with the Criterion B water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity. New storage would provide increased operational flexibility and would supplement releases from existing facilities.

If no new storage is implemented under Alternative 2, summer releases from existing facilities may increase up to 1,400 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 2, releases may decrease as much as 1,300 cfs or increase up to 300 cfs relative to the No Action Alternative. During winter months, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in Alternative 2, necessitates increased flood control releases in winter months.

With new storage under Alternative 2, summer releases from existing facilities may increase relative to the No Action Alternative. Without new storage under Alternative 2, releases may decrease or increase relative to the No Action Alternative.

Average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative by implementation of Alternative 2. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.



Figure 5.2-40. Average Monthly San Joaquin River Flow at Vernalis under Alternative 2 for the Long-Term Period

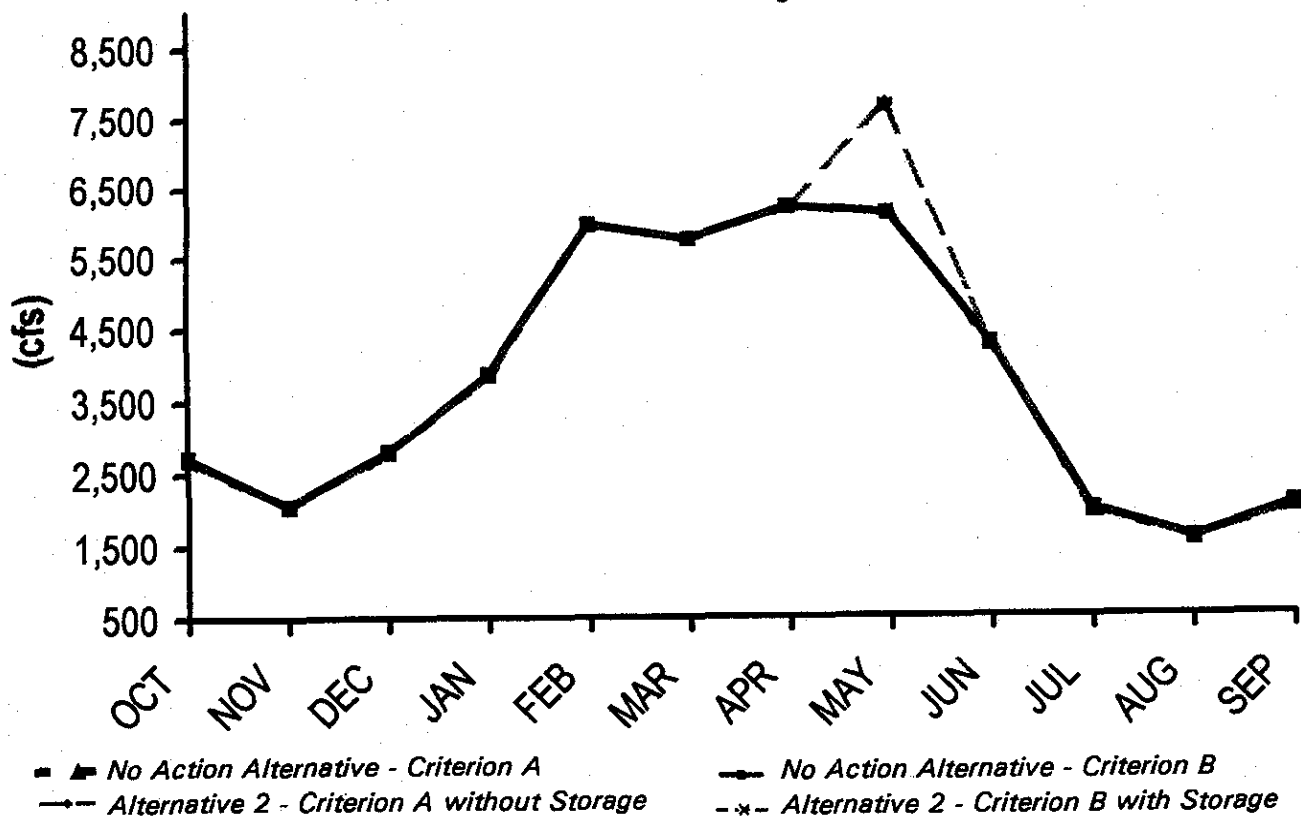


Figure 5.2-41. Average Monthly San Joaquin River Flow at Vernalis under Alternative 2 for Dry and Critical Years

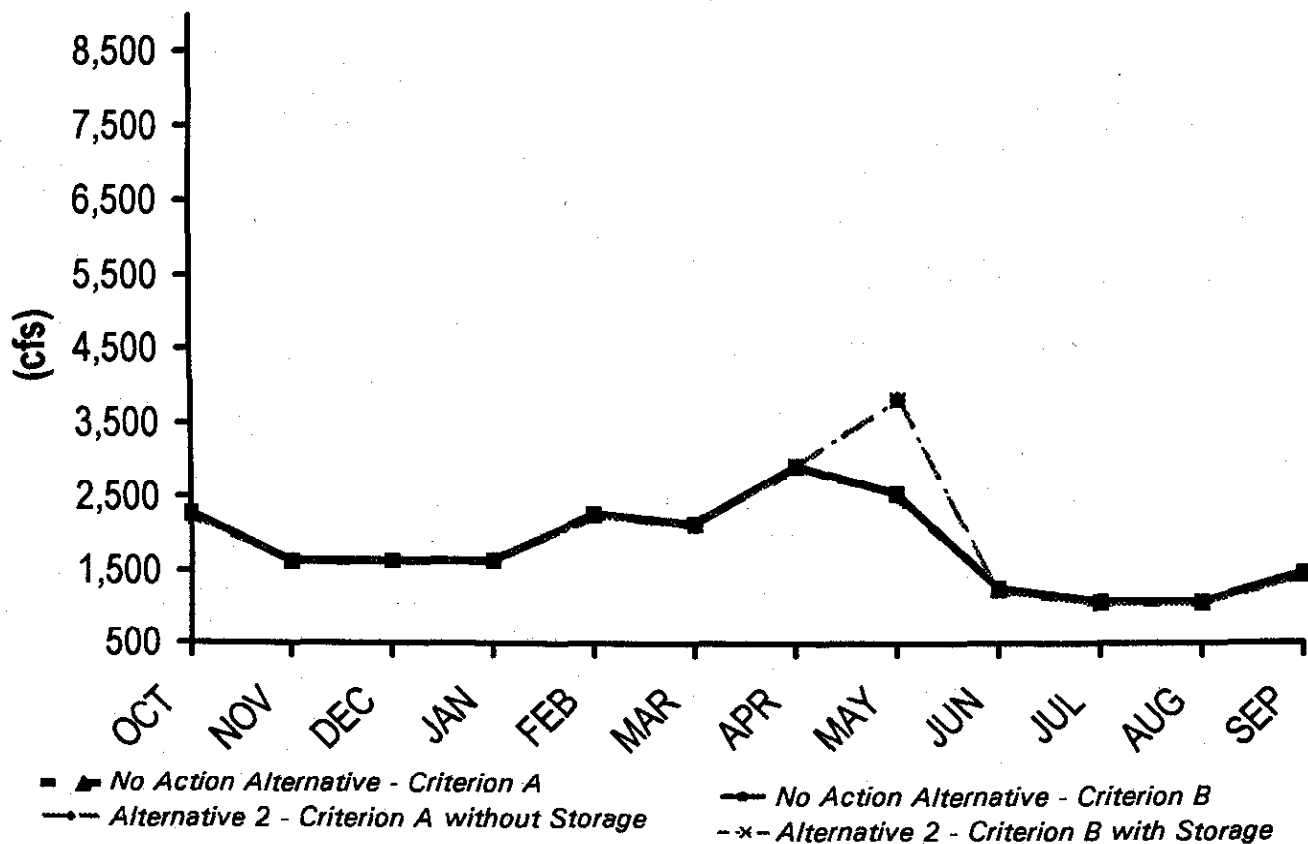


Figure 5.2-42. New Surface Storage Diversions in the Sacramento River Region under Alternative 2 for the Long-Term Period

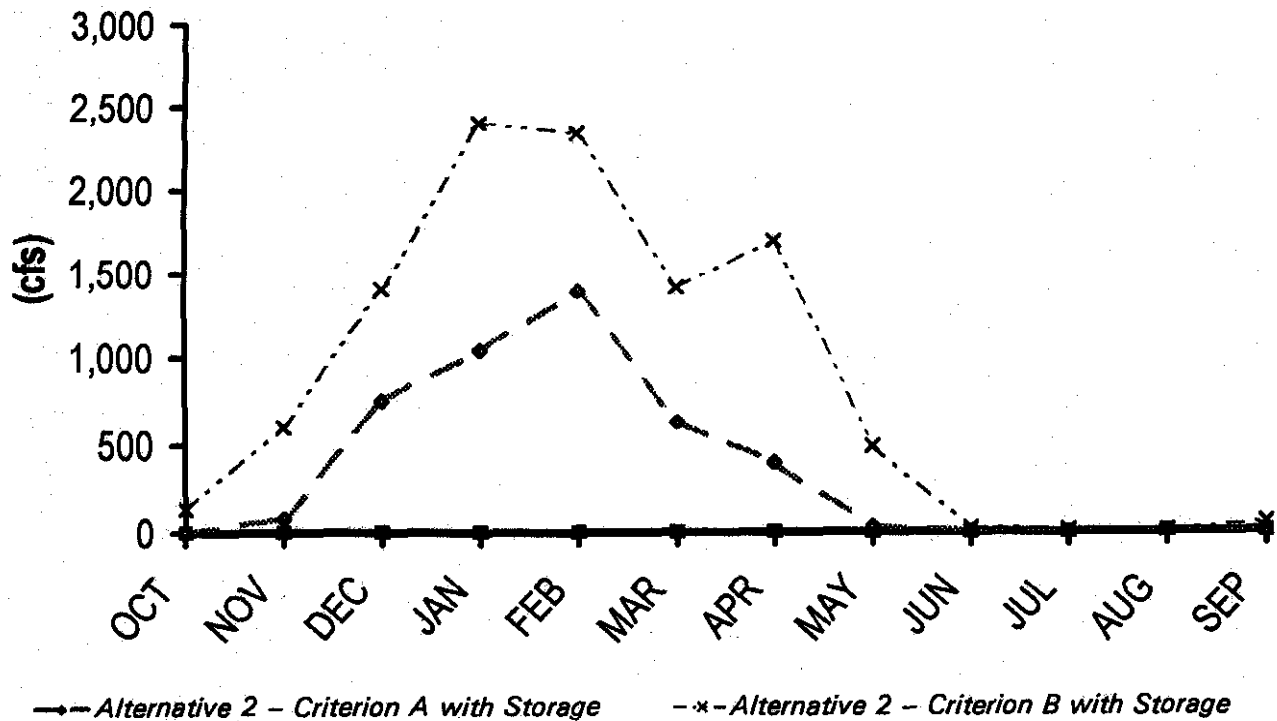
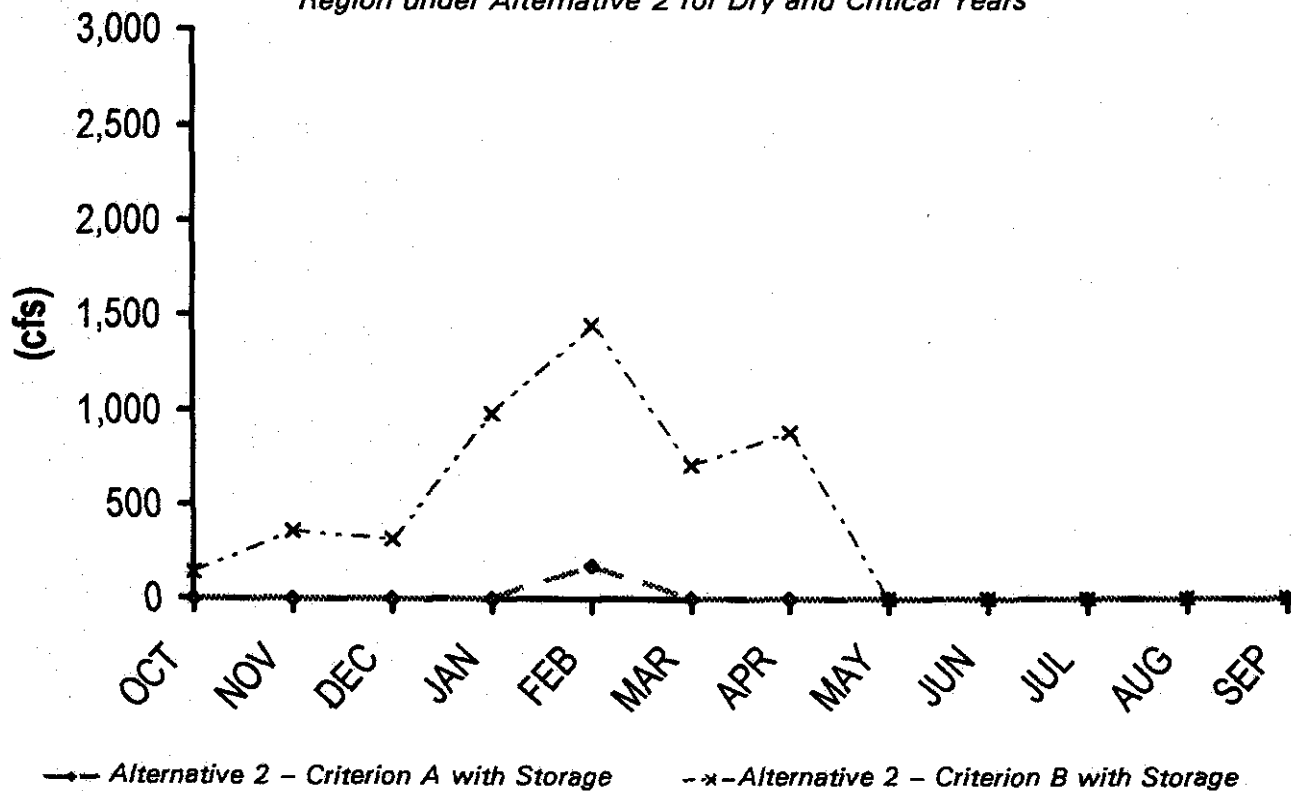


Figure 5.2-43. New Surface Storage Diversions in the Sacramento River Region under Alternative 2 for Dry and Critical Years



New Reservoir Diversions and Releases. Figures 5.2-42 and 5.2-43 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under Alternative 2. Under Alternative 2, new surface storage diversions typically occur during winter and spring, with peak diversions in late winter. Over the long-term period, the range of peak average monthly diversions is 1,400-2,300 cfs. For dry and critical years, the range of peak average monthly diversions is 200-1,400 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer when the greatest environmental benefits are anticipated—with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. Environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Maximum average monthly releases in dry and critical years are on the order of 1,200 cfs, while maximum average monthly releases are approximately 900 cfs for the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Under Alternative 2, peak average monthly releases range from 1,700-2,600 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,200-2,200 cfs.

New San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Under Alternative 2, maximum diversions during dry and critical years occur in early summer (120 cfs), while average monthly diversions over the long-term period are greatest in late winter (170 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under Alternative 2. Under Alternative 2, maximum average monthly releases range from 550 to 560 cfs for the long-term period, from 340-350 cfs for dry and critical years.

Average monthly San Joaquin Region reservoir releases are unchanged from the No Action Alternative by implementation of Alternative 2.

5.2.8.3 ALTERNATIVE 3

For evaluation purposes, Alternative 3 was simulated with a 5,000- and 15,000-cfs isolated conveyance facility. Evaluation of the smaller configuration assumes that full south Delta improvements are in place. Evaluation of the larger configuration assumes a subset of the south Delta improvements are in place and includes service to Delta islands along the route of the canal. To fully describe potential consequences of Alternative 3, the 15,000-cfs isolated conveyance facility is evaluated under Criterion A assumptions and the 5,000-cfs isolated conveyance facility is evaluated under Criterion B assumptions. See Attachment A for further details.

For evaluation purposes, Alternative 3 was simulated with a 5,000- and 15,000-cfs isolated conveyance facility.



Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross Delta, Old River at Bacon Island, and San Joaquin River at Antioch), water levels (stage), and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, this analysis focuses on a few key locations. Channel flows are described at five locations and stage is described at two locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs.

Alternative 3 decreases flow by as much as 7,400 cfs in February and by as much as 2,800 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occurs in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, Alternative 3 decreases flow by as much as 4,400 cfs in February and by as much as 1,400 cfs in September. Figures 5.2-44 and 5.2-45 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

QWEST Flow. QWEST flow was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about -4,000 to -4,300 cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400-3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from -4,900 to -5,200 cfs.

Alternative 3 increases average monthly positive QWEST flow over the long-term period in April by as much as 2,100 cfs and decreases average monthly reverse QWEST flow in October by as much as 5,700 cfs. During dry and critical years, Alternative 3 increases average monthly positive QWEST flow in April by as much as 1,900 cfs and decreases average monthly reverse QWEST flow in December by as much as 6,700 cfs. Figures 5.2-46 and 5.2-47 compare average monthly QWEST flow for the long-term period and for dry and critical years, respectively.

Alternative 3 decreases flows in the Sacramento River at Rio Vista.

Alternative 3 increases and decreases QWEST flow.



Figure 5.2-44. Average Monthly Sacramento River Flow at Rio Vista under Alternative 3 for the Long-Term Period

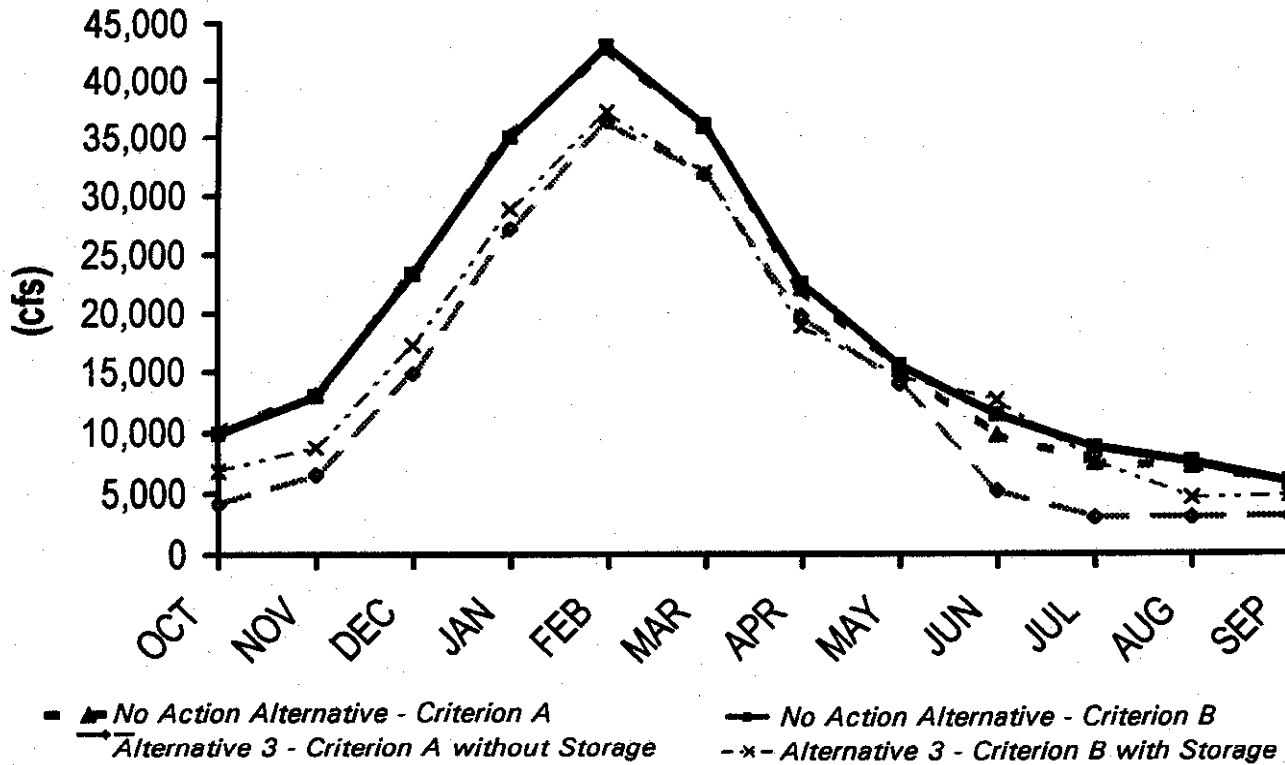


Figure 5.2-45. Average Monthly Sacramento River Flow at Rio Vista under Alternative 3 for Dry and Critical Years

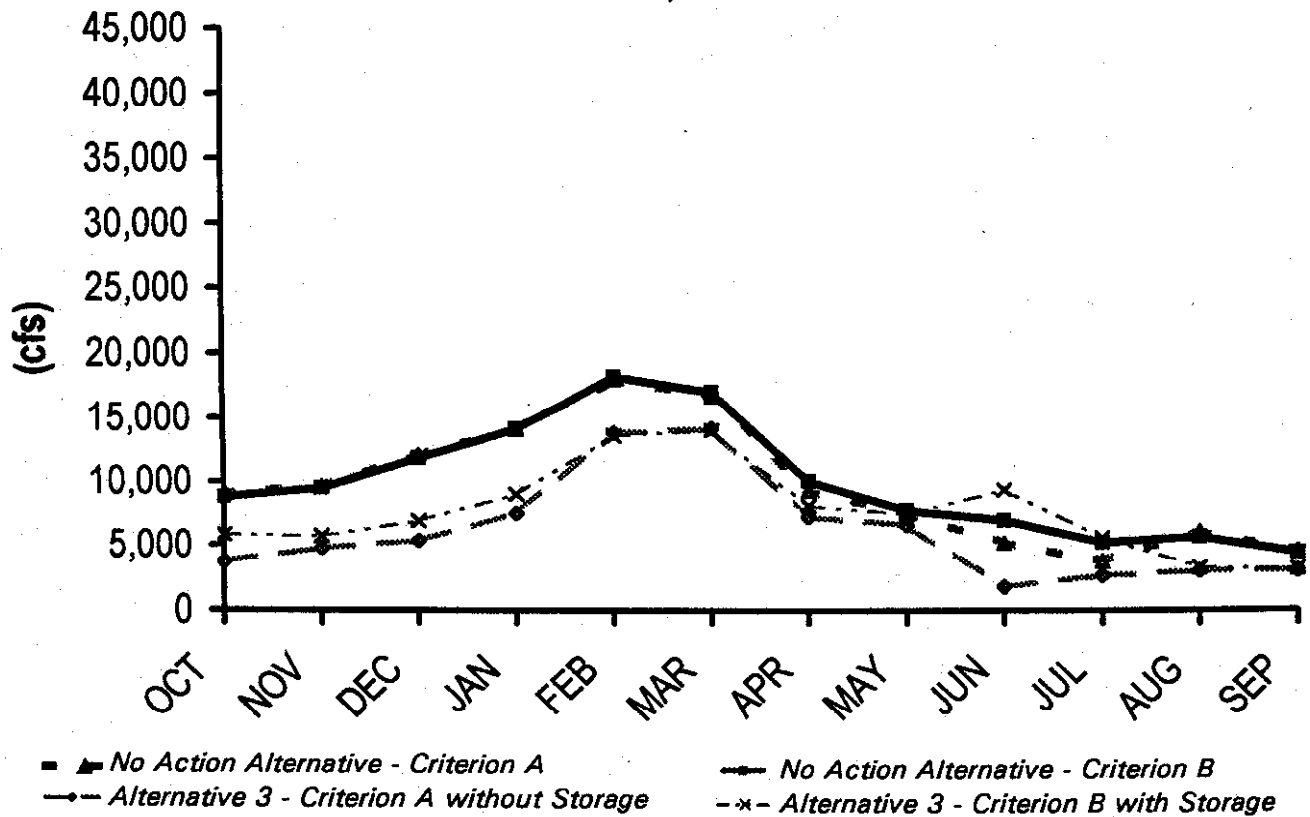


Figure 5.2-46. Average Monthly QWEST Flow under Alternative 3
for the Long-Term Period

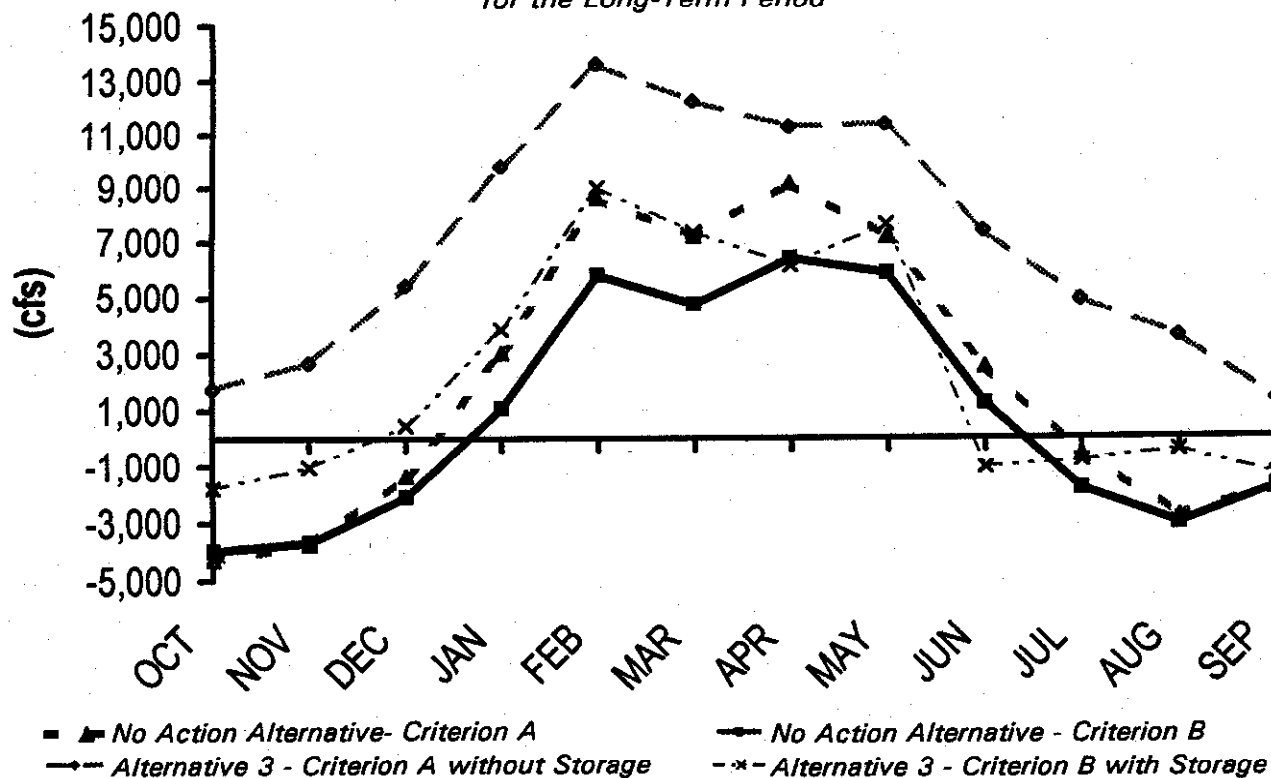
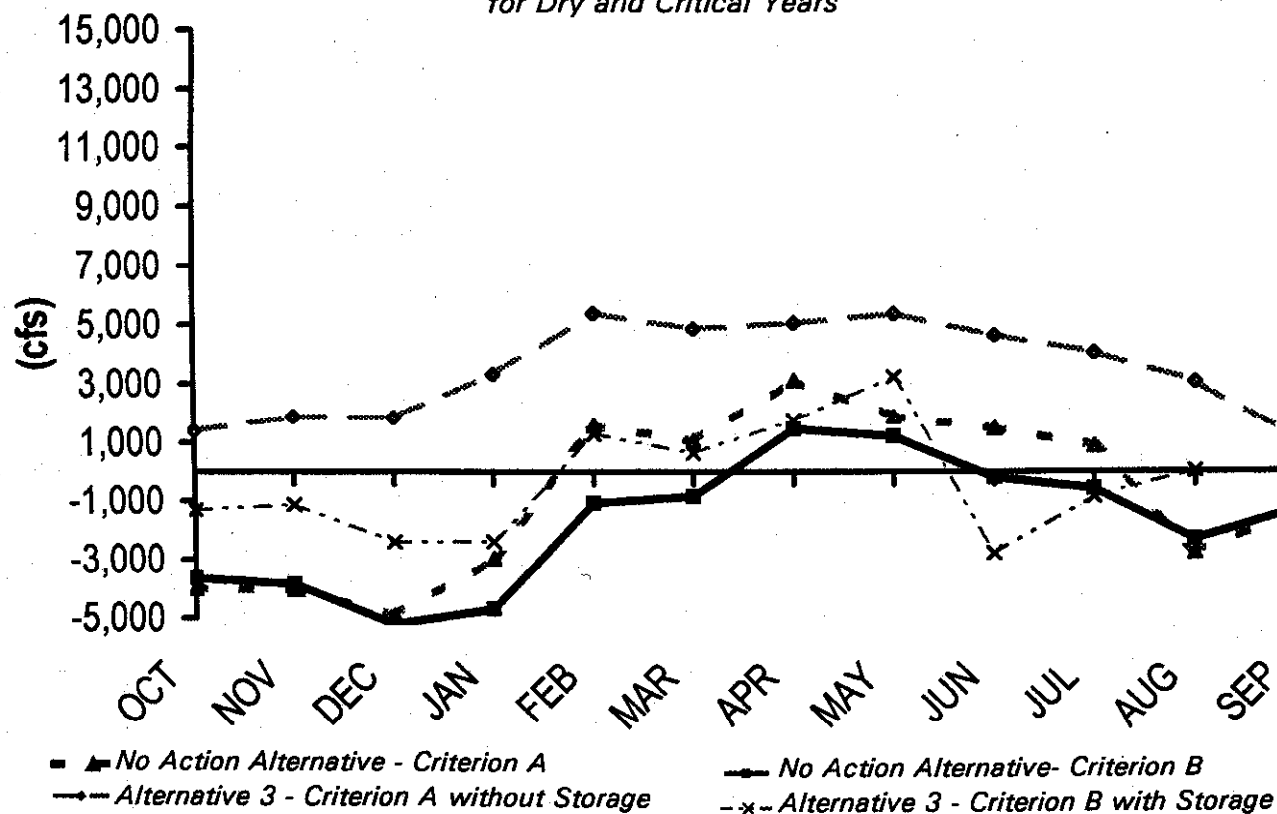


Figure 5.2-47. Average Monthly QWEST Flow under Alternative 3
for Dry and Critical Years



Cross-Delta Flow. Cross-Delta flow was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Differences in cross-Delta flow are best summarized by flows occurring in August, December and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, and averages 2,400 cfs in December and 1,800 cfs in May.

Under Alternative 3, over the long-term period and in dry and critical years, cross-Delta flow typically decreases in August, December and May. Over the long-term period under Alternative 3, decreases in cross-Delta flow range from 1,700 to 2,800 cfs in August, from 800 to 1,300 cfs in December and from 200 to 400 cfs in May. During dry and critical years under Alternative 3, decreases in cross-Delta flow range from 1,700 to 2,000 cfs in August, from 800 to 1,300 cfs in December and from 200 to 500 cfs in May. Figures 5.2-48 and 5.2-49 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Under Alternative 3, over the long-term period and in dry and critical years, cross-Delta flow typically decreases in August, December and May.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about -3,400 cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from -3,000 to -3,600 cfs.

Over the long-term period under Alternative 3, decreases in reverse flow in Old River at Bacon Island in August range from 1,700 to 3,000 cfs, resulting in flow ranging from -400 to -1,700 cfs. In dry and critical years under Alternative 3, decreases in reverse flow in August range from 2,100 to 2,400 cfs, resulting in flow ranging from -600 to -1,000 cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for Alternative 3 and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from -1,000 to -1,200 cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from -2,100 to -2,400 cfs.

Average monthly San Joaquin River flow at Antioch ranges from 2,100 to 4,100 cfs in August over the long-term period under Alternative 3. In dry and critical years under Alternative 3, reverse flow decreases in August range from 3,000 to 3,700 cfs, resulting in flow ranging from 2,700 to 3,500 cfs. Decreases in reverse flow in December range from 1,900 to 5,000 cfs under Alternative 3 in dry and critical years, resulting in flow ranging from -150 to 2,900 cfs.



Figure 5.2-48. Average Monthly Cross-Delta Flow under Alternative 3 for the Long-Term Period

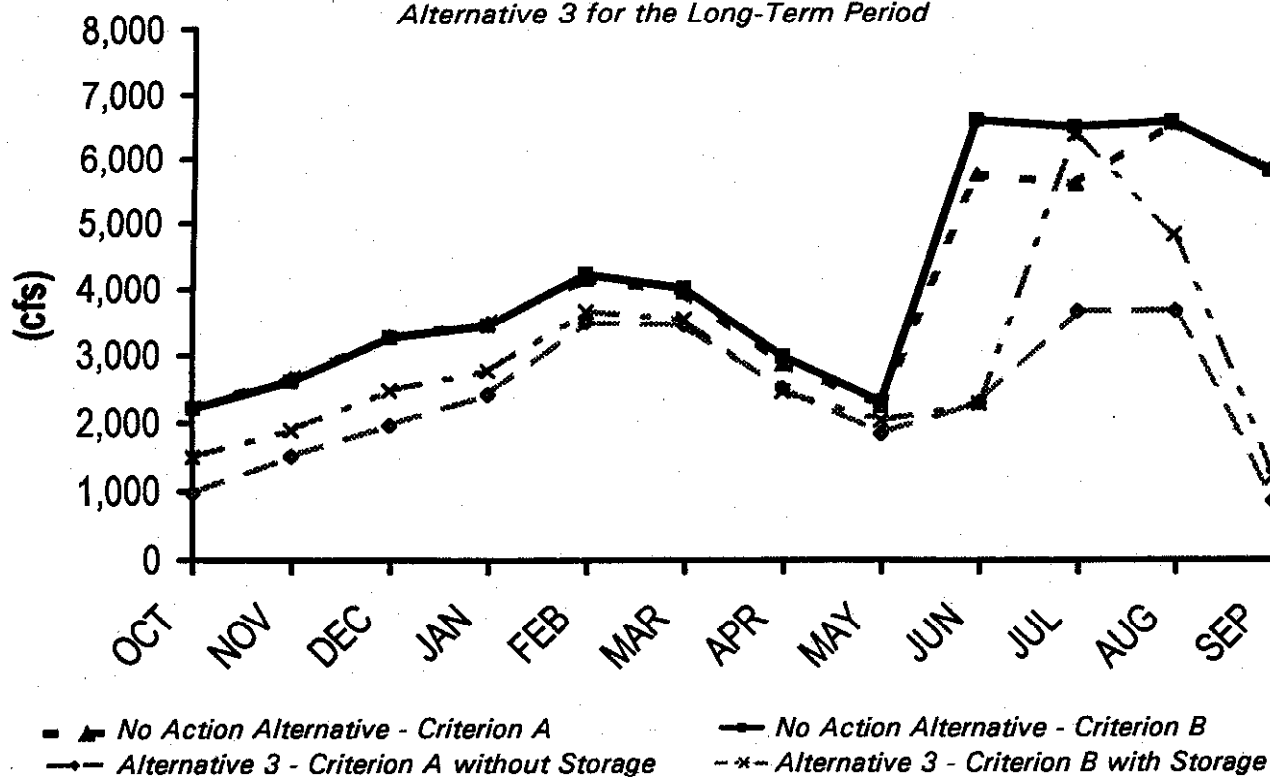
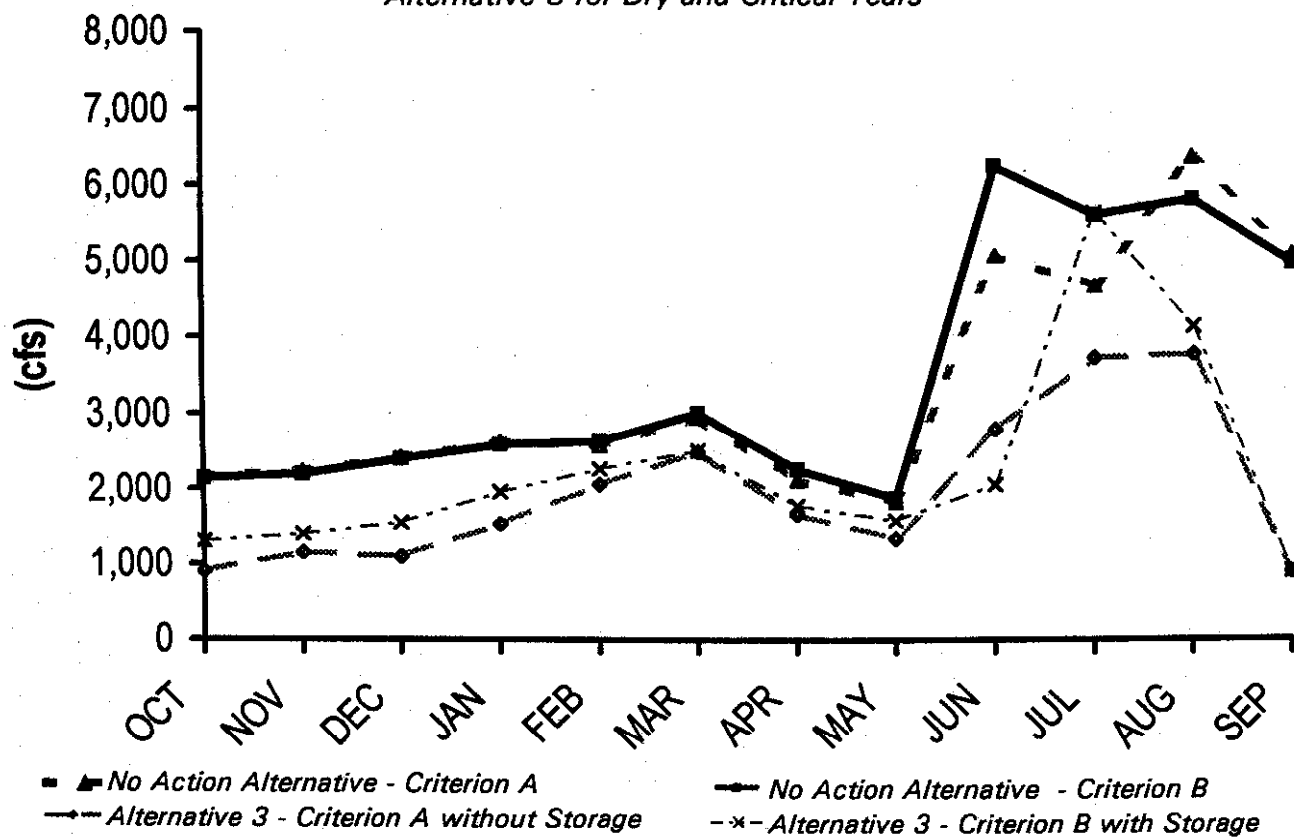


Figure 5.2-49. Average Monthly Cross-Delta Flow under Alternative 3 for Dry and Critical Years



Stage

The monthly average minimum stages in Middle River and in Old River were evaluated for the No Action Alternative and Alternative 3 for the long-term period and dry and critical years. Flow control structures under Alternative 3 with a 5,000-cfs isolated conveyance facility configuration (same as described above for Alternative 1) are operated from April through October for all hydrologic periods for this evaluation. Flow control structures are not included in Alternative 3 with a 15,000-cfs isolated conveyance facility configuration.

Middle River Upstream of Victoria Island. Over the long-term period under the No Action Alternative, the highest minimum stage in Middle River typically occurs in February and March and is about 0.1 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl.

In the absence of new surface storage, Alternative 3 increases water levels by an average of 0.2 foot during the operation period, resulting in water surface elevations ranging from 0 to 0.5 foot below msl. Implementing new surface storage under Alternative 3 increases water levels by an average of 2.1 feet during the operation period, resulting in water surface elevations ranging from 1.3 to 1.9 feet above msl. During dry and critical years under the No Action Alternative, the highest minimum stage in Middle River typically occurs in April and is about 0.5 foot below msl. The lowest minimum stage typically occurs in September and is about 0.7 foot below msl.

Alternative 3 stage improvements for dry and critical years are similar to those described for the long-term period, and resulting water levels range from 0.3 to 0.5 foot below msl in the absence of new surface storage and from 1.4 to 1.8 feet above msl under the implementation of new surface storage.

Old River Flow at Bacon Island. Over the long-term period under the No Action Alternative, the highest minimum stage in Old River typically occurs in February and March and is about 0.6 foot above msl. The lowest minimum stage typically occurs in August and is about 0.7 foot below msl.

In the absence of new surface storage, Alternative 3 increases water levels by an average of 0.3 foot from June through September, resulting in water surface elevations ranging from 0.4 foot below to 0.3 foot above msl. Implementing new surface storage under Alternative 3 increases water levels by an average of 2.2 feet during the operation period, resulting in water surface elevations ranging from 1.6 to 1.9 feet above msl. In November under Alternative 3, monthly average minimum stage may decrease by up to 0.3 foot due to the implementation of new surface storage, resulting in water surface elevations as low as 0.6 foot below msl. During dry and critical years under the No Action Alternative, the highest minimum stage in Old River typically occurs in April and is about 0.3 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl.

With new surface storage, Alternative 3 increases water levels at Old River. Without new surface storage, Alternative 3 increases and decreases water elevations at Old River.



Alternative 3 stage improvements for dry and critical years are similar to those described for the long-term period, and resulting water levels range from 0.3 to 0.5 foot below msl in the absence of new surface storage. With new surface storage, water elevations range from 1.3 to 1.7 feet above msl. Water level decreases in November for dry and critical years are similar to those experienced for the long-term period and resulting water surface elevations are as low as 0.8 foot below msl.

Mass Fate

The DSM2 model was used to perform several mass tracking simulations for Alternative 3. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Section 5.2.8.4.

Bay Region

Bay-Delta X2 position was evaluated for the No Action Alternative and Alternative 3 for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

Alternative 3 may increase average monthly X2 position by about 1.1 km or may decrease X2 position by 2.3 km in September. Alternative 3 may increase X2 position by about 0.8 km or decrease X2 position by 0.3 km in March. During dry and critical years under the No Action alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. Alternative 3 decreases average monthly X2 position by about 3.9 km in September and by about 0.4 km in March. Alternative 3 also may increase monthly X2 position in March during dry and critical years by about 1.2 km. Figures 5.2-50 and 5.2-51 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

Alternative 3 may increase or decrease the Bay-Delta X2 position.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between Alternative 3 and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under Alternative 3. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an instream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B under the modeling analysis.



Figure 5.2-50. Average Monthly X2 Position under Alternative 3 for the Long-Term Period

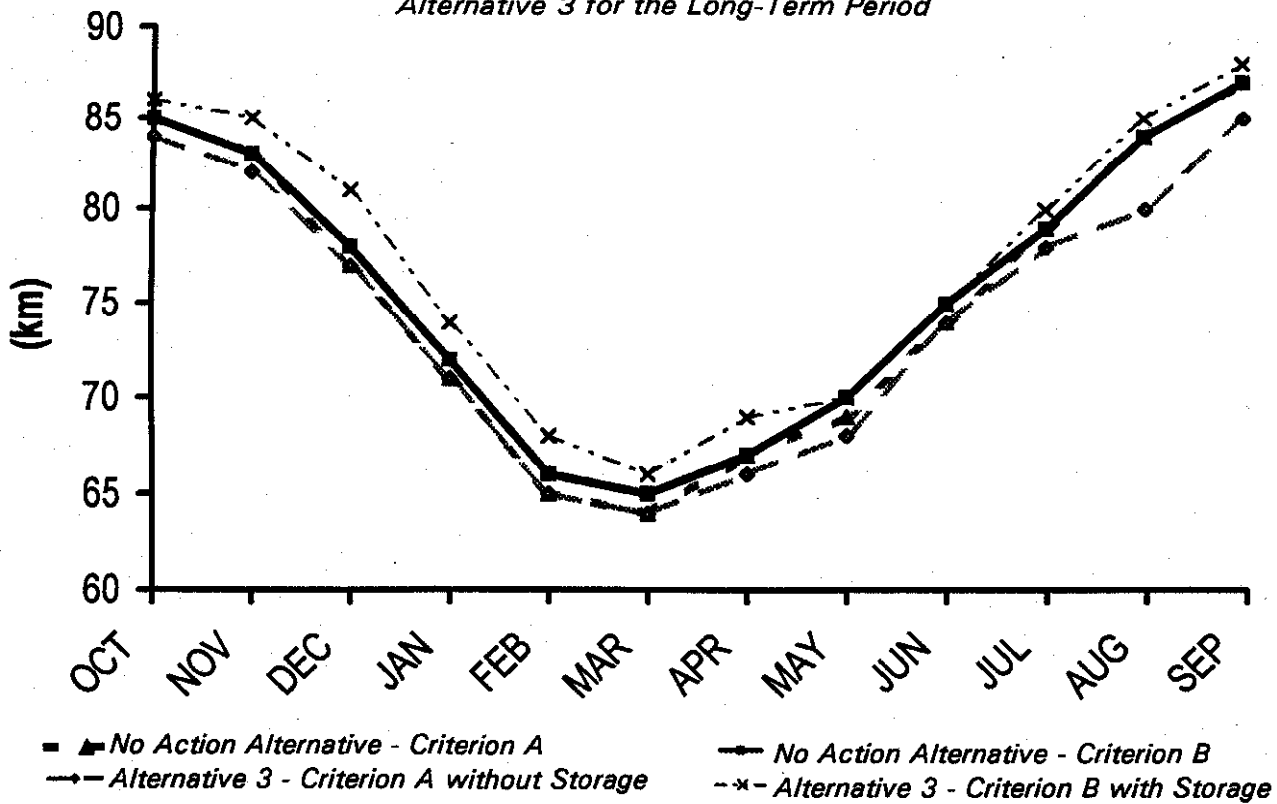


Figure 5.2-51. Average Monthly X2 Position under Alternative 3 for Dry and Critical Years

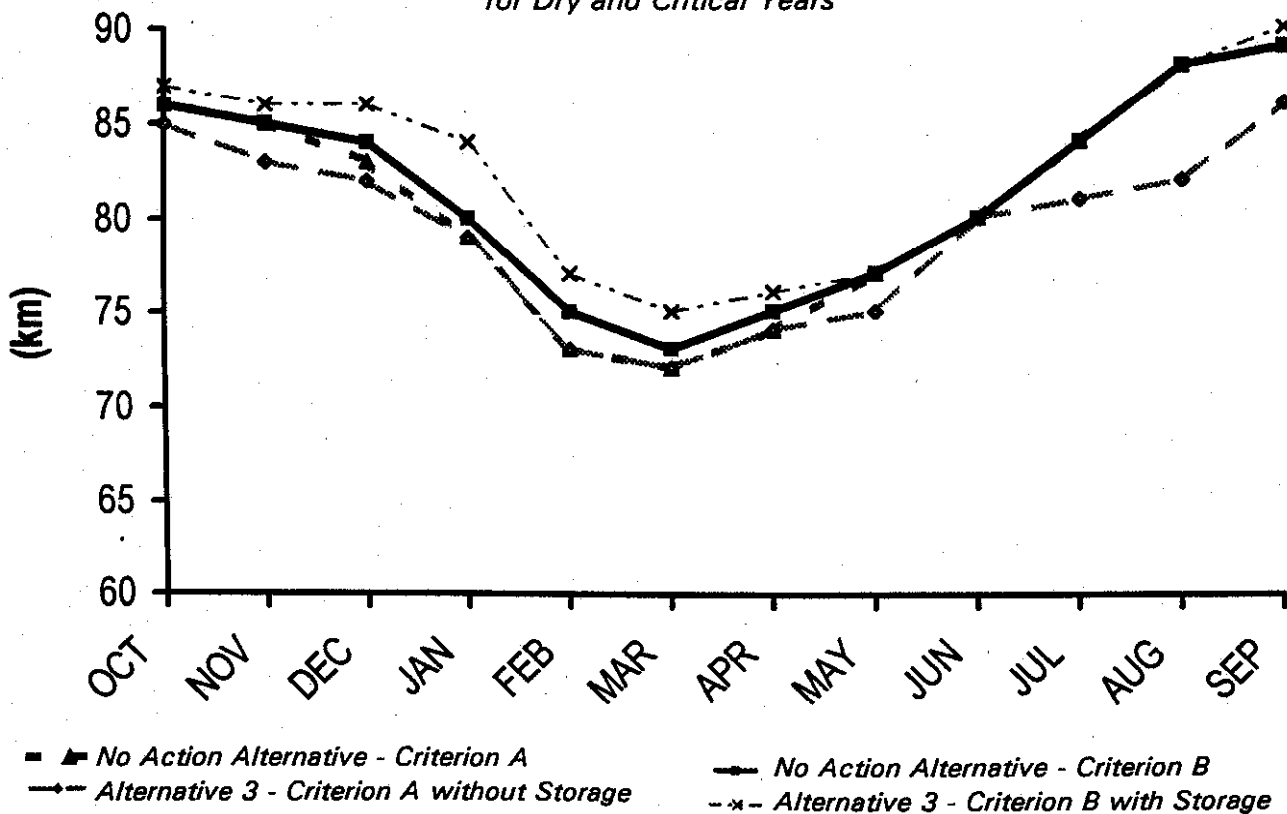


Figure 5.2-52. Average Monthly Sacramento River Flow at Freeport under Alternative 3 for the Long-Term Period

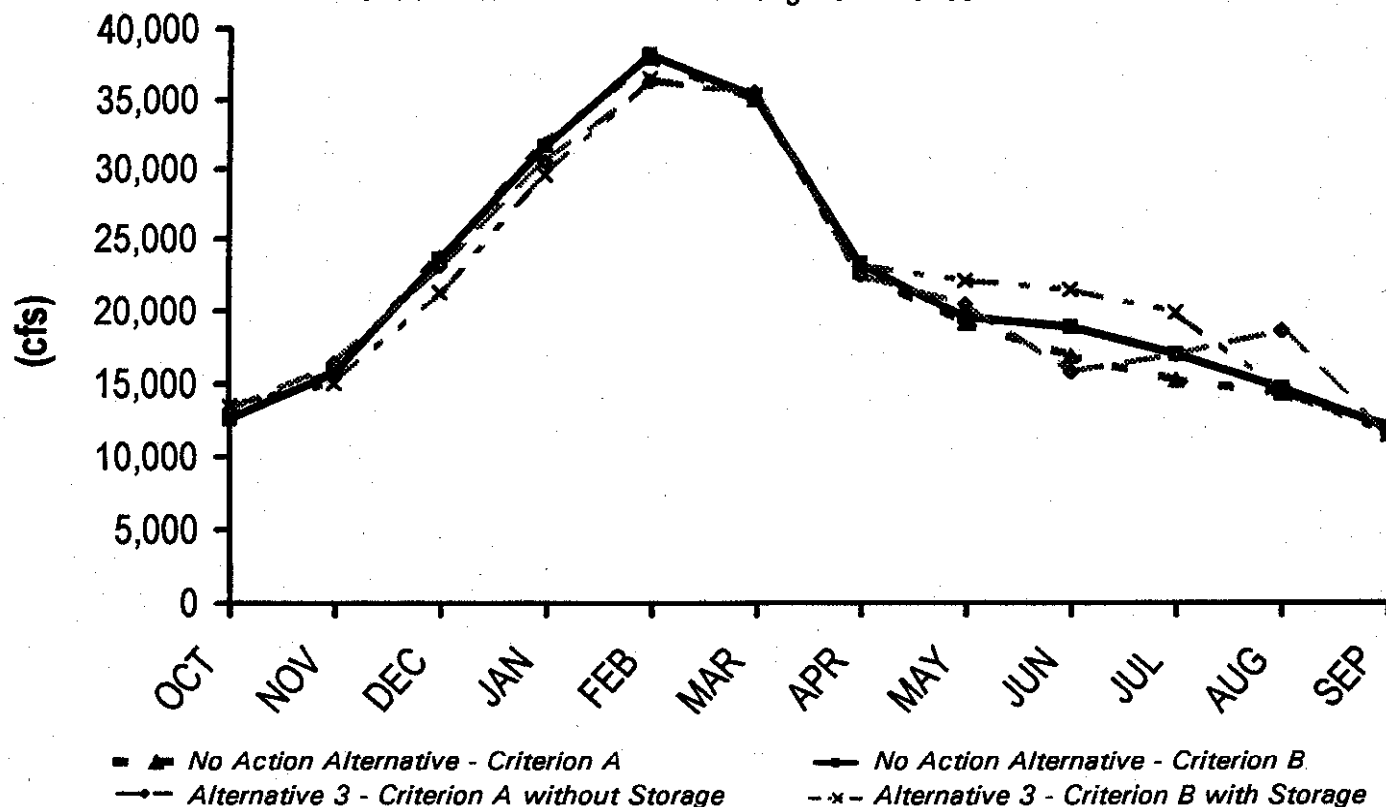


Figure 5.2-53. Average Monthly Sacramento River Flow at Freeport under Alternative 3 for Dry and Critical Years

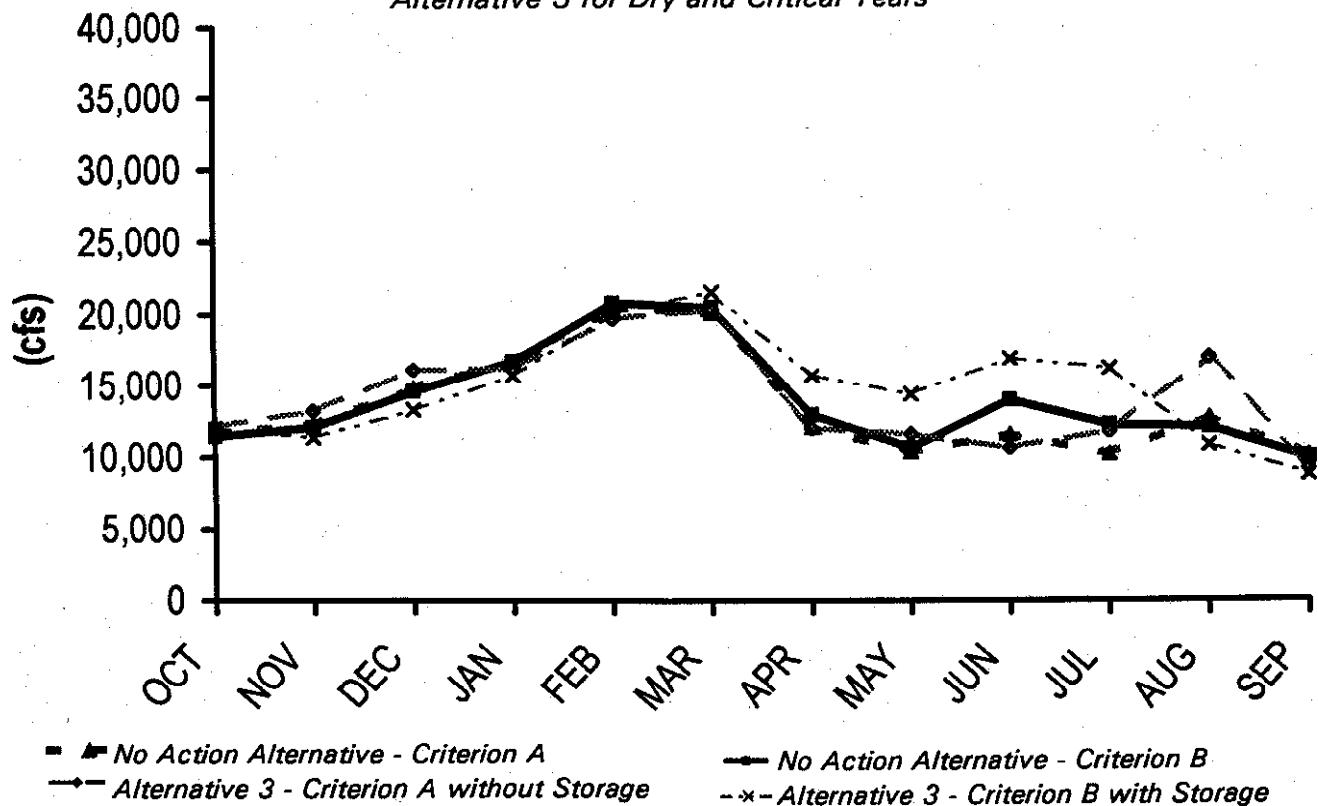


Figure 5.2-54. Average Monthly San Joaquin River Flow at Vernalis under Alternative 3 for the Long-Term Period

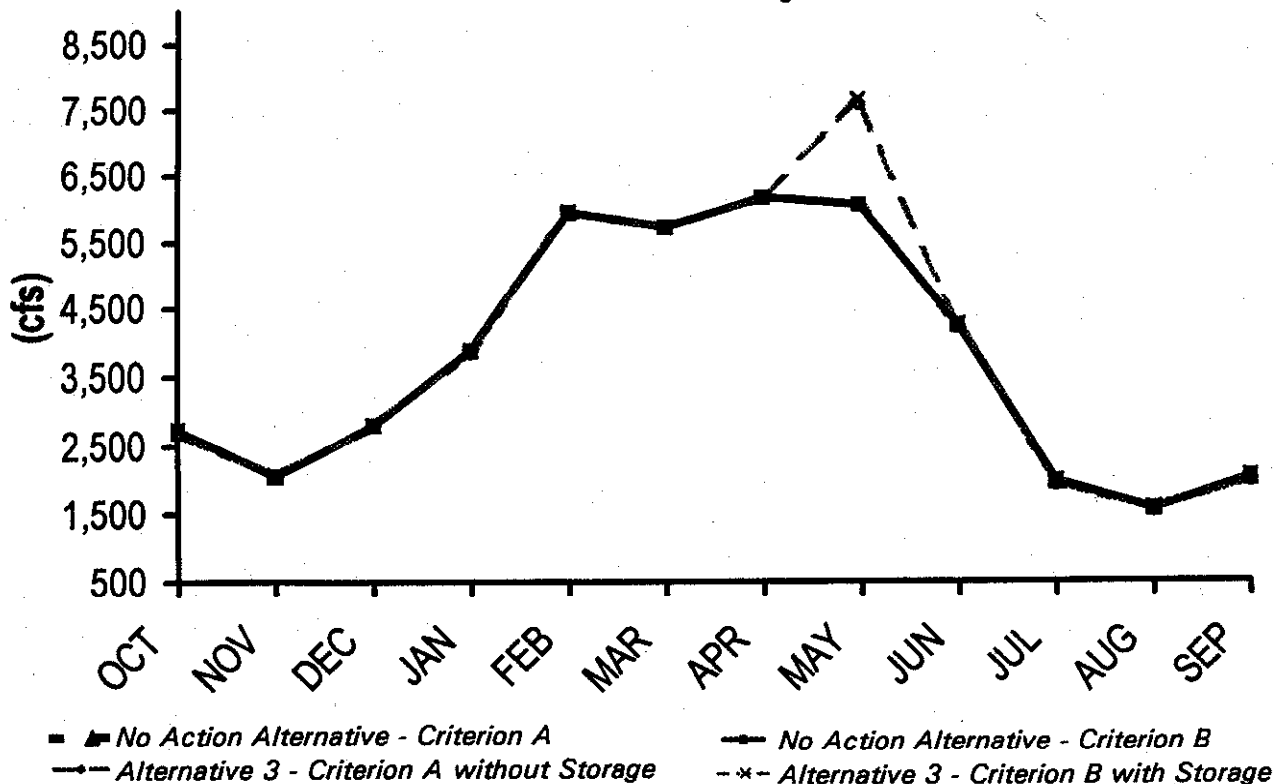
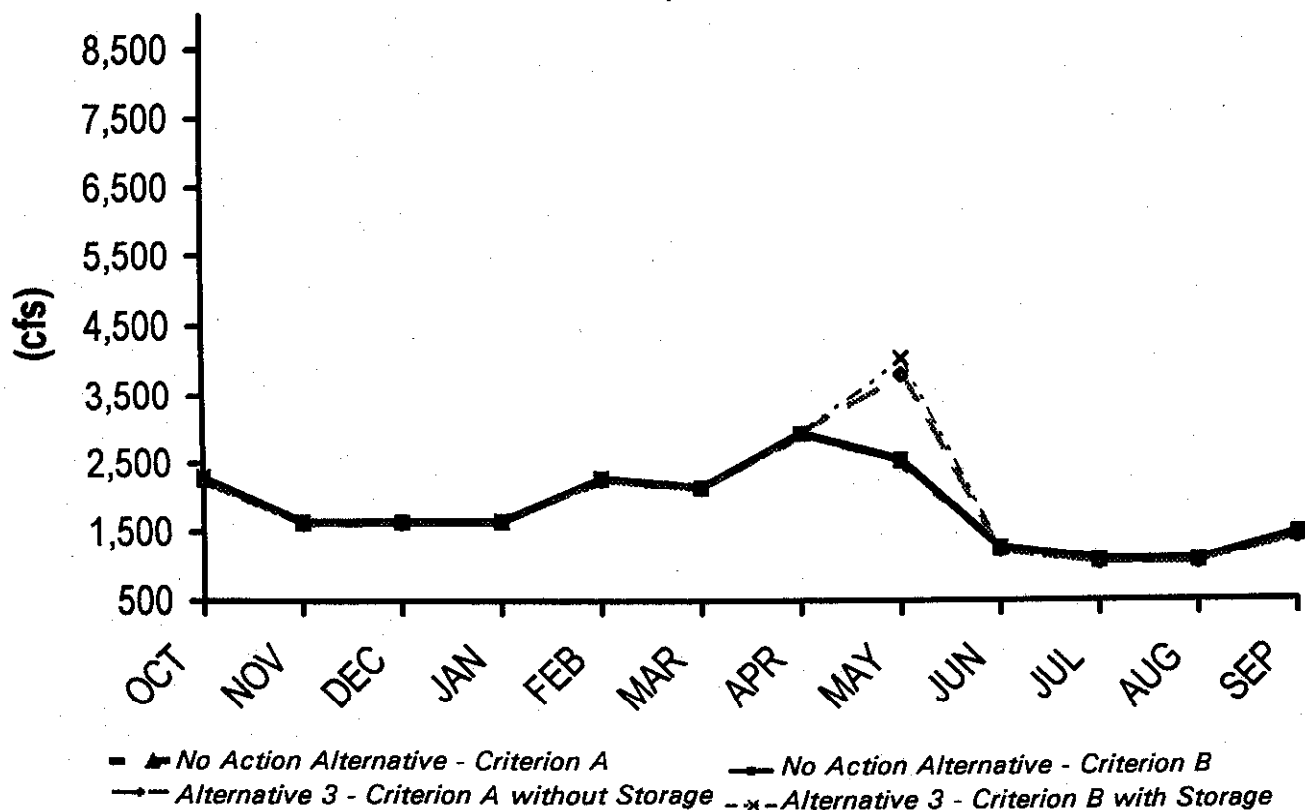


Figure 5.2-55. Average Monthly San Joaquin River Flow at Vernalis under Alternative 3 for Dry and Critical Years



River Flows. Average monthly flow in the Sacramento River at Freeport was evaluated for Alternative 3 and the No Action Alternative. Figures 5.2-52 and 5.2-53 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

In the absence of new storage facilities, Alternative 3 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer months under both hydrologic periods. Alternative 3 may increase average monthly flow by as much as 2,900 cfs during the summer. Even with new storage facilities, Alternative 3 has little impact on average monthly flow in most months. Flow increases are most pronounced during summers of dry and critical years—up to 4,000 cfs.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for Alternative 3 and the No Action Alternative. Figures 5.2-54 and 5.2-55 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under Alternative 3, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring. Alternative 3 increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. Similarly, in dry and critical years, Alternative 3 increases average monthly flow in spring by as much as 1,500 cfs.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer months under the No Action Alternative as well as under Alternative 3. This pattern is consistent for the long-term period and dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs. Under Alternative 3, the lowest long-term period summer releases are generally associated with the Criterion A water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity. New storage would provide increased operational flexibility and would supplement releases from existing facilities.

If no new storage is implemented under Alternative 3, summer releases from existing facilities may increase up to 1,600 cfs relative to the No Action Alternative. If new storage is implemented under Alternative 3, releases may increase as much as 1,300 cfs relative to the No Action Alternative. During winter months, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in Alternative 3, necessitates increased flood control releases in winter months.

Under Alternative 3, average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.

Alternative 3 has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative.

Under Alternative 3, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring.

With or without new storage under Alternative 3, summer releases from existing facilities may increase relative to the No Action Alternative.

Under Alternative 3, average monthly San Joaquin Region reservoir releases are unchanged from the No Action Alternative.



Figure 5.2-56. New Surface Storage Diversions in the Sacramento River Region under Alternative 3 for the Long-Term Period

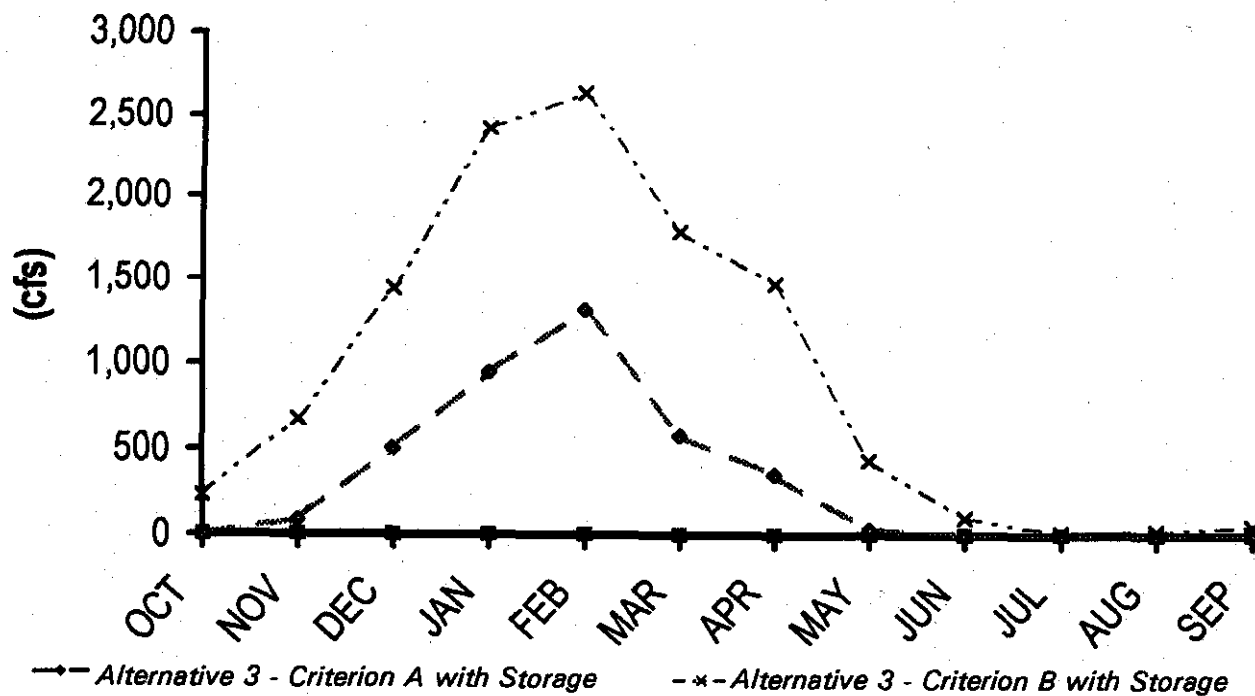
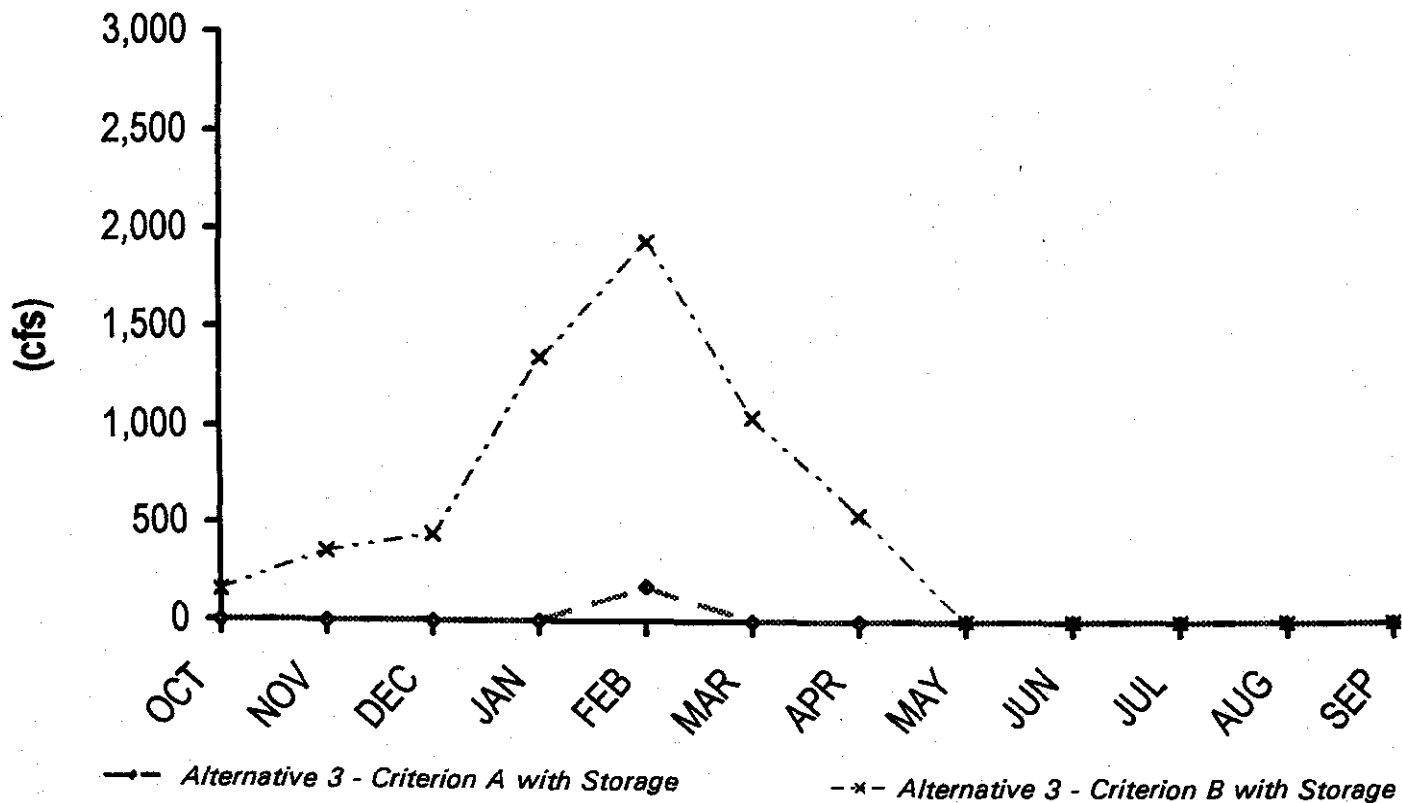


Figure 5.2-57. New Surface Storage Diversions in the Sacramento River Region under Alternative 3 for Dry and Critical Years



New Reservoir Diversions and Releases. Figures 5.2-56 and 5.2-57 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under Alternative 3. Under Alternative 3, new surface storage diversions typically occur during winter and spring months, with peak diversions in late winter. Over the long-term period, the range of peak average monthly diversions is from 1,300 to 2,600 cfs. For dry and critical years, the range of peak average monthly diversions is from 200 to 1,900 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer months when the greatest environmental benefits are anticipated, with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. For the long-term period, environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Under Alternative 3, maximum average monthly releases in dry and critical years are on the order of 1,000 cfs, while maximum average monthly releases are approximately 800 cfs over the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Under Alternative 3, peak average monthly releases range from 400 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,200 to over 2,700 cfs.

San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Maximum diversions during dry and critical years occur in early summer (160 cfs), while average monthly diversions over the long-term period are greatest in late winter (230 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under Alternative 3. Maximum average monthly releases are approximately 570 cfs for the long-term period and 360 cfs for dry and critical years.

5.2.8.4 PREFERRED PROGRAM ALTERNATIVE

For evaluation purposes, the Preferred Program Alternative was simulated with and without a new screened diversion (2,000-4,000 cfs) from the Sacramento River near Hood to the Mokelumne River system. Without the new diversion, consequences of the Preferred Program Alternative relative to Bay-Delta hydrodynamics and riverine hydraulics are similar to consequences under Alternative 1, as described in Section 5.2.8.1. Consequences of the Preferred Program Alternative with a new diversion are described below.

For evaluation purposes, the Preferred Program Alternative was simulated with and without a new screened diversion (2,000-4,000 cfs) from the Sacramento River near Hood to the Mokelumne River system.



Figure 5.2-58. Sacramento River Flow at Rio Vista under the Preferred Program Alternative for the Long-Term Period

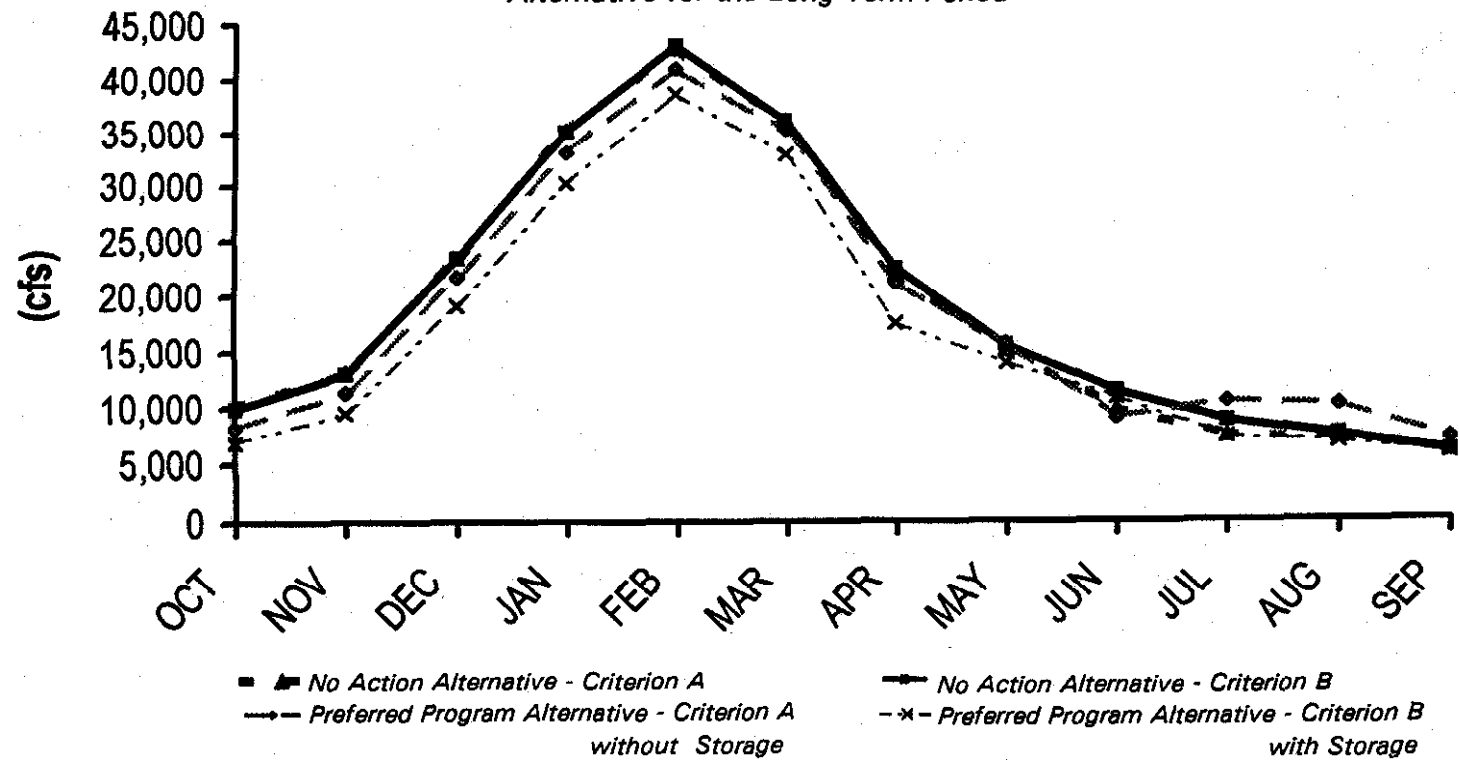
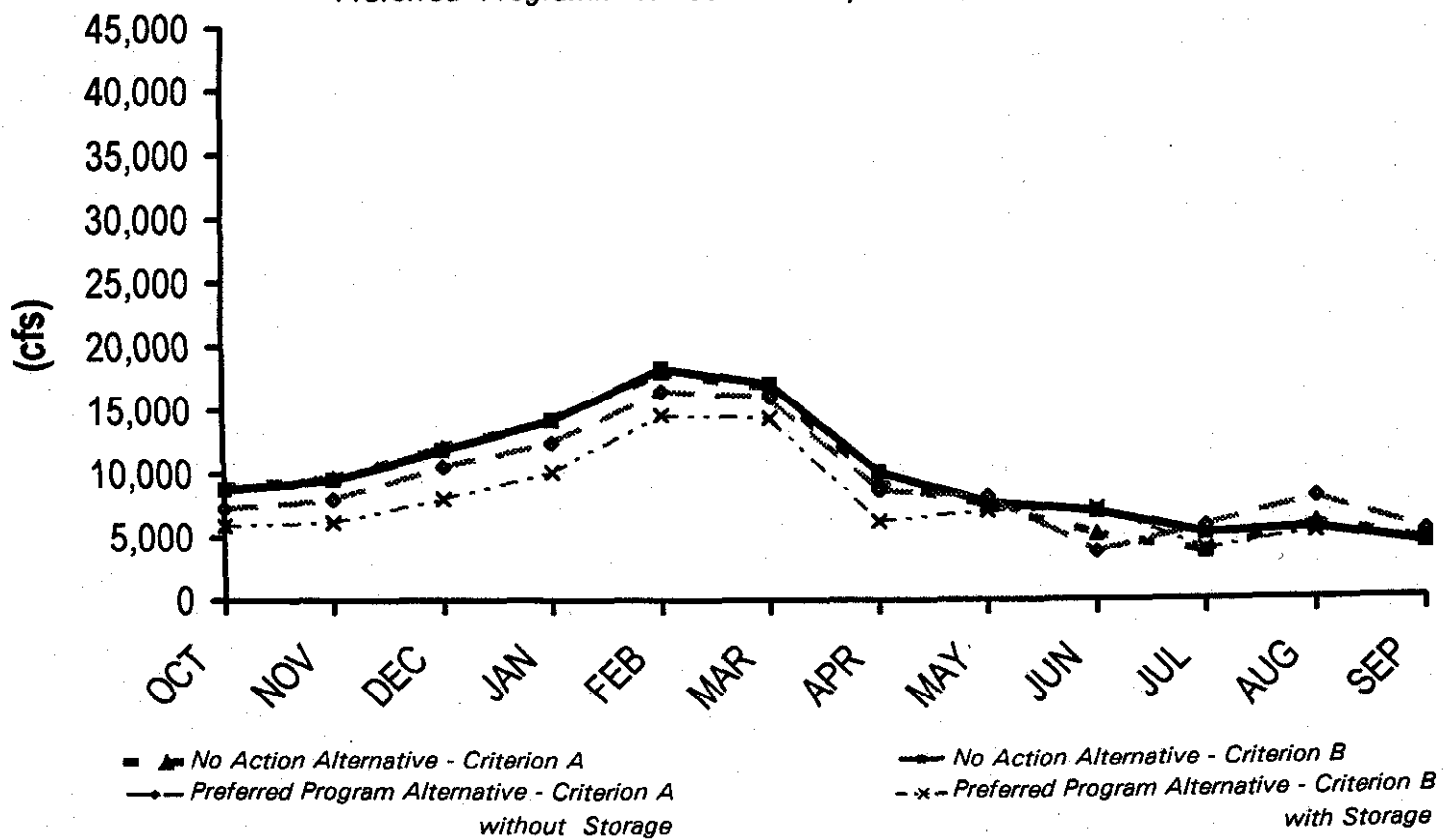


Figure 5.2-59. Average Monthly Sacramento River Flow at Rio Vista under the Preferred Program Alternative for Dry and Critical Years



Delta Region

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows (cross Delta, Old River at Bacon Island, and San Joaquin River at Antioch), water levels (stage), and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows (Sacramento River at Rio Vista and QWEST) and X2 position. To provide a programmatic overview, this analysis focuses on a few key locations. Channel flows are described at five locations and stage is described at two locations.

Channel Flows

Sacramento River Flow at Rio Vista. Average monthly Rio Vista flow was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Under the No Action Alternative, the highest average long-term period flow typically occurs in February and is approximately 42,700 cfs; the lowest flow typically occurs in September and averages about 5,900 cfs. The Preferred Program Alternative decreases flow by as much as 4,100 cfs in February. The Preferred Program Alternative modifies flow by -300 to 1,600 cfs in September.

During dry and critical years, the highest average No Action Alternative flow occur in February and is about 18,000 cfs. The lowest average Rio Vista flow typically occurs in September and is about 4,400 cfs. During dry and critical years, the Preferred Program Alternative decreases flow in February by as much as 3,400 cfs. In September, the Preferred Program Alternative modifies flow by -300 to 1,600 cfs. Figures 5.2-58 and 5.2-59 compare average monthly Rio Vista flow for the long-term period and for dry and critical years, respectively.

Rio Vista flow under the Preferred Program Alternative also was compared with Rio Vista flow under the other Program alternatives. The long-term period comparison is summarized in Table 5.2-3. The dry and critical year comparison is summarized in Table 5.2-4. Additionally, Figures 5.2-60 and 5.2-61 present Rio Vista flow comparisons for the long-term period and dry and critical years, respectively.

The Delta hydrodynamic and water quality model, DSM2, was used to assess channel flows, water levels, and mass fate throughout the Delta Region. The systems operations model, DWRSIM, was used to assess channel flows and X2 position.

Table 5.2-3. Sacramento River Flow at Rio Vista under All Program Alternatives for the Long-Term Period (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak monthly flow (February)	42,600-42,900	41,600-42,500	34,100-39,300	35,200-37,900	38,400-40,800
Low monthly flow (September)	5,800-5,900	5,700-6,100	3,200-5,200	3,000-4,800	5,500-7,400

Note:

PPA = Preferred Program Alternative.



Figure 5.2-60. September Sacramento River Flows at Rio Vista under All Program Alternatives for the Long-Term Period

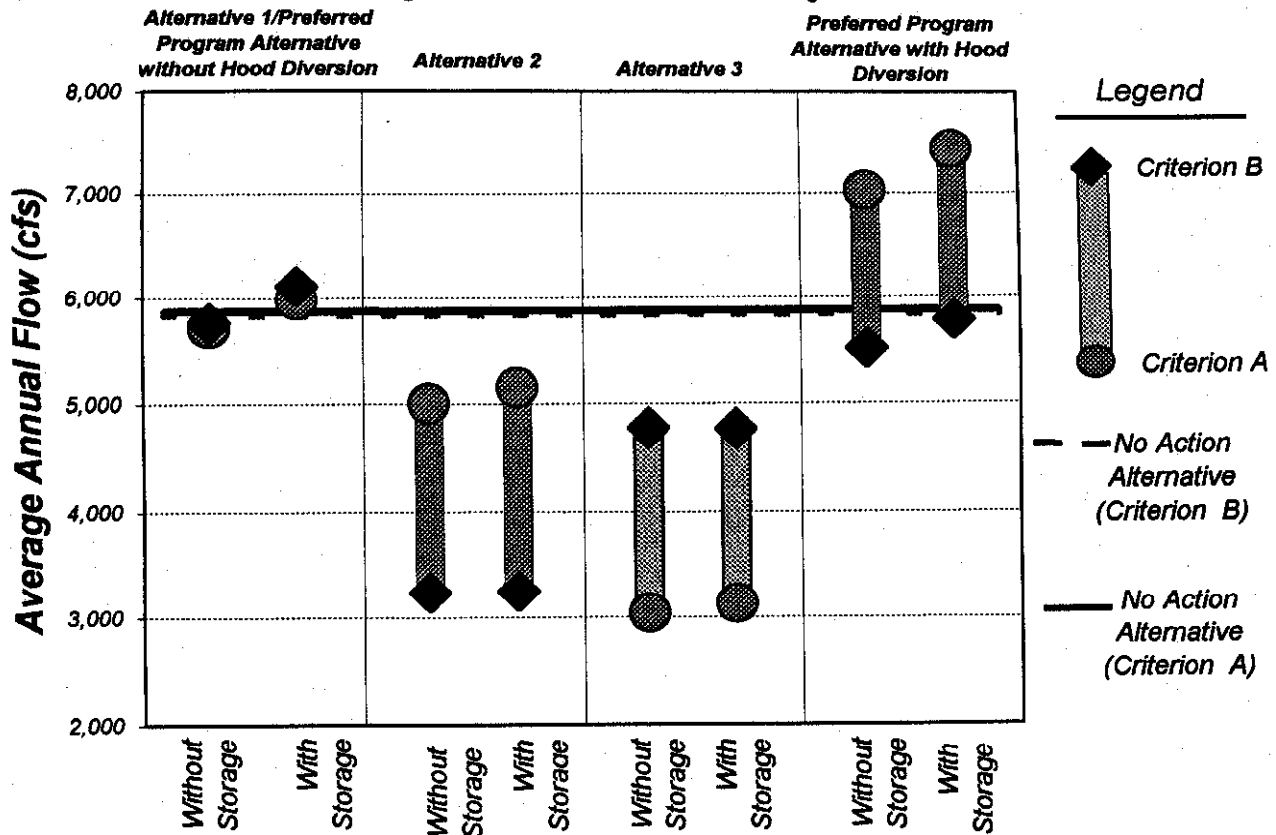


Figure 5.2-61. September Sacramento River Flows at Rio Vista under All Program Alternatives for Dry and Critical Years

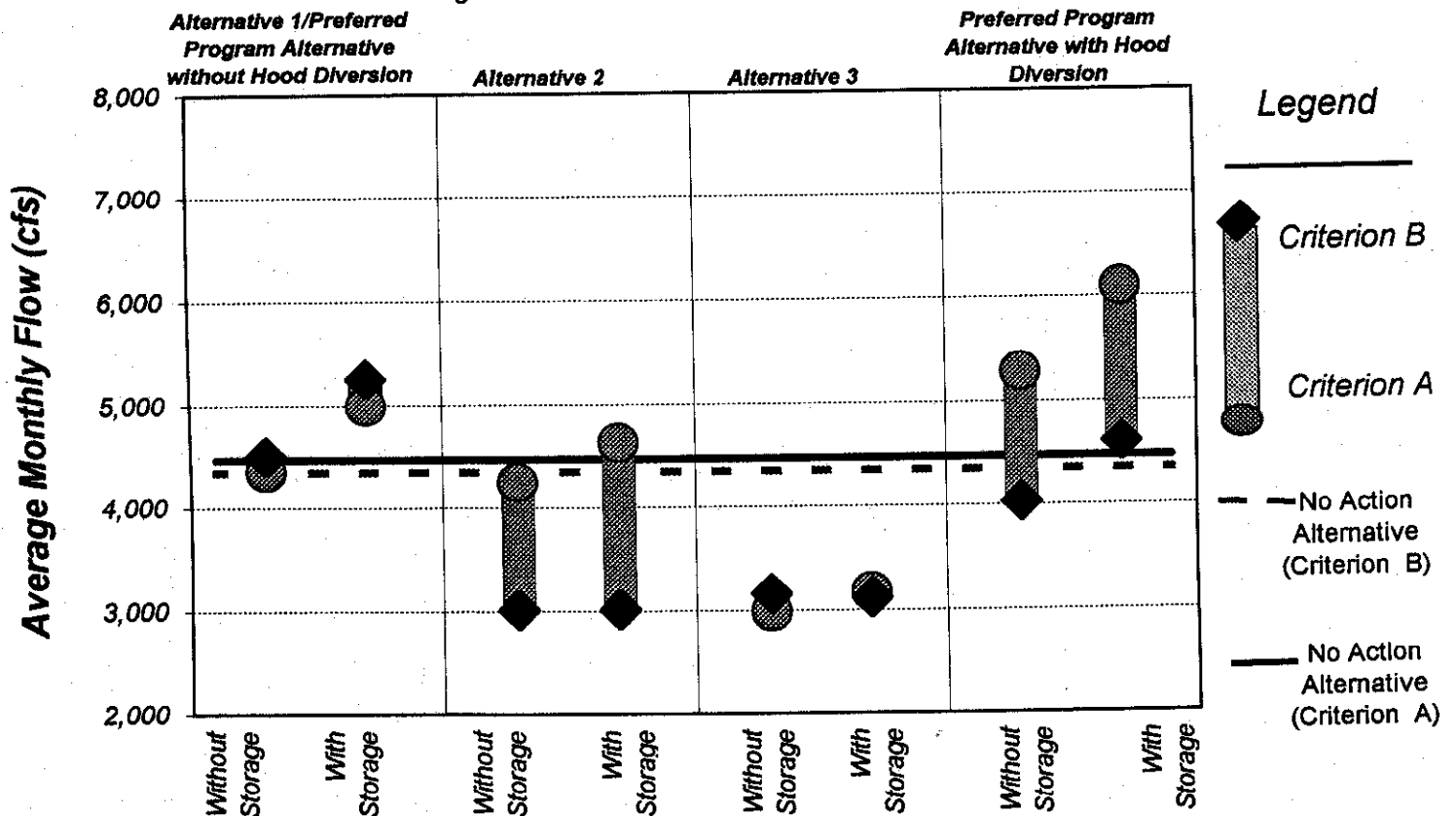


Table 5.2-4. Sacramento River Flow at Rio Vista under All Program Alternatives for Dry and Critical Years (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak monthly flow (February)	17,900-18,100	17,800-18,000	11,000-15,700	13,600-14,400	14,500-16,400
Low monthly flow (September)	4,300-4,500	4,300-5,300	3,000-4,600	3,000-3,200	4,000-6,100

Note:
PPA = Preferred Program Alternative

QWEST Flow. QWEST flow was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly positive QWEST flow typically occurs in April and ranges from about 6,400 to 9,100 cfs. The greatest average monthly negative (reverse) QWEST flow typically occurs in October and ranges from about -4,000 to -4,300 cfs. Reverse flow is due to a combination of tidal effects, reduced reservoir releases, and Delta exports. During dry and critical years under the No Action Alternative, the greatest average monthly positive QWEST flow occurs in April and ranges from 1,400 to 3,100 cfs. The greatest average monthly reverse flow typically occurs in December and ranges from -4,900 to -5,200 cfs.

The Preferred Program Alternative increases average monthly positive QWEST flow over the long-term period in April by as much as 900 cfs and decreases average monthly reverse QWEST flow in October by as much as 2,500 cfs. During dry and critical years, the Preferred Program Alternative increases average monthly positive QWEST flow in April by as much as 1,200 cfs and decreases average monthly reverse QWEST flow in December by as much as 2,400 cfs. Figures 5.2-62 and 5.2-63 compare average monthly QWEST flow for the long-term period and for dry and critical years, respectively.

QWEST flow under the Preferred Program Alternative also was compared with QWEST flow under the other Program alternatives. The long-term period comparison is summarized in Table 5.2-5. The dry and critical year comparison is summarized in Table 5.2-6. Additionally, Figures 5.2-64 and 5.2-65 present Delta export comparisons for the long-term period and dry and critical years, respectively.

Cross-Delta Flow. Cross-Delta flow was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Differences in cross-Delta flow are best summarized by flows occurring in August, December and May. Over the long-term period under the No Action Alternative, average monthly cross-Delta flow averages 6,500 cfs in August, 3,300 cfs in December and 2,300 cfs in May. In dry and critical years under the No Action Alternative, average monthly cross-Delta flow ranges from 5,800 to 6,300 cfs in August, and averages 2,400 cfs in December and 1,800 cfs in May. Under the Preferred Program Alternative, over the long-term period and in dry and critical years, cross-Delta flow may increase or decrease in August, whereas

The Preferred Program Alternative increases average monthly positive QWEST flow over the long-term period in April by as much as 900 cfs and decreases average monthly reverse QWEST flow in October by as much as 2,500 cfs.

Under the Preferred Program Alternative, over the long-term period and in dry and critical years, cross-Delta flow may increase or decrease in August, whereas cross-Delta flow in December and May typically increases.



Figure 5.2-62. Average Monthly QWEST Flow under the Preferred Program Alternative for the Long-Term Period

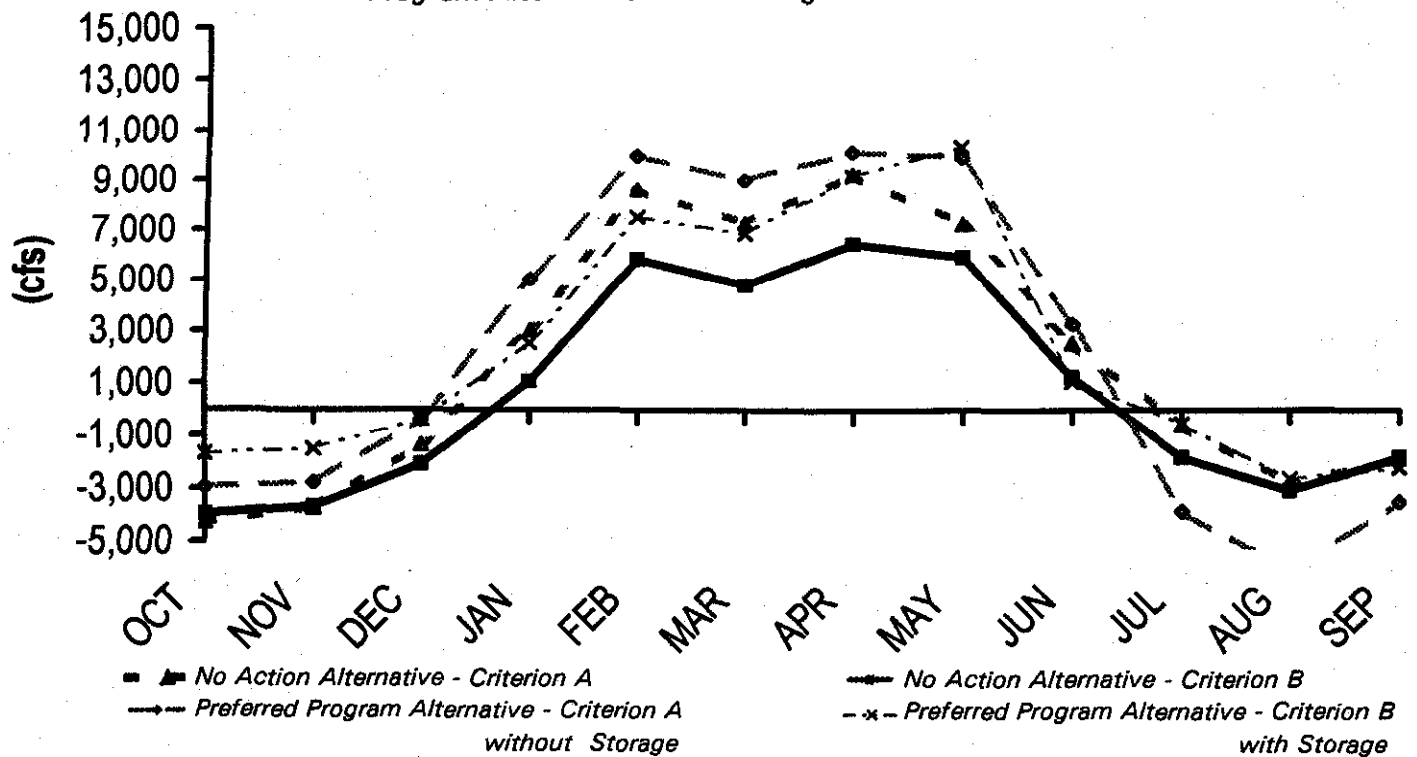


Figure 5.2-63. Average Monthly QWEST Flow under the Preferred Program Alternative for Dry and Critical Years

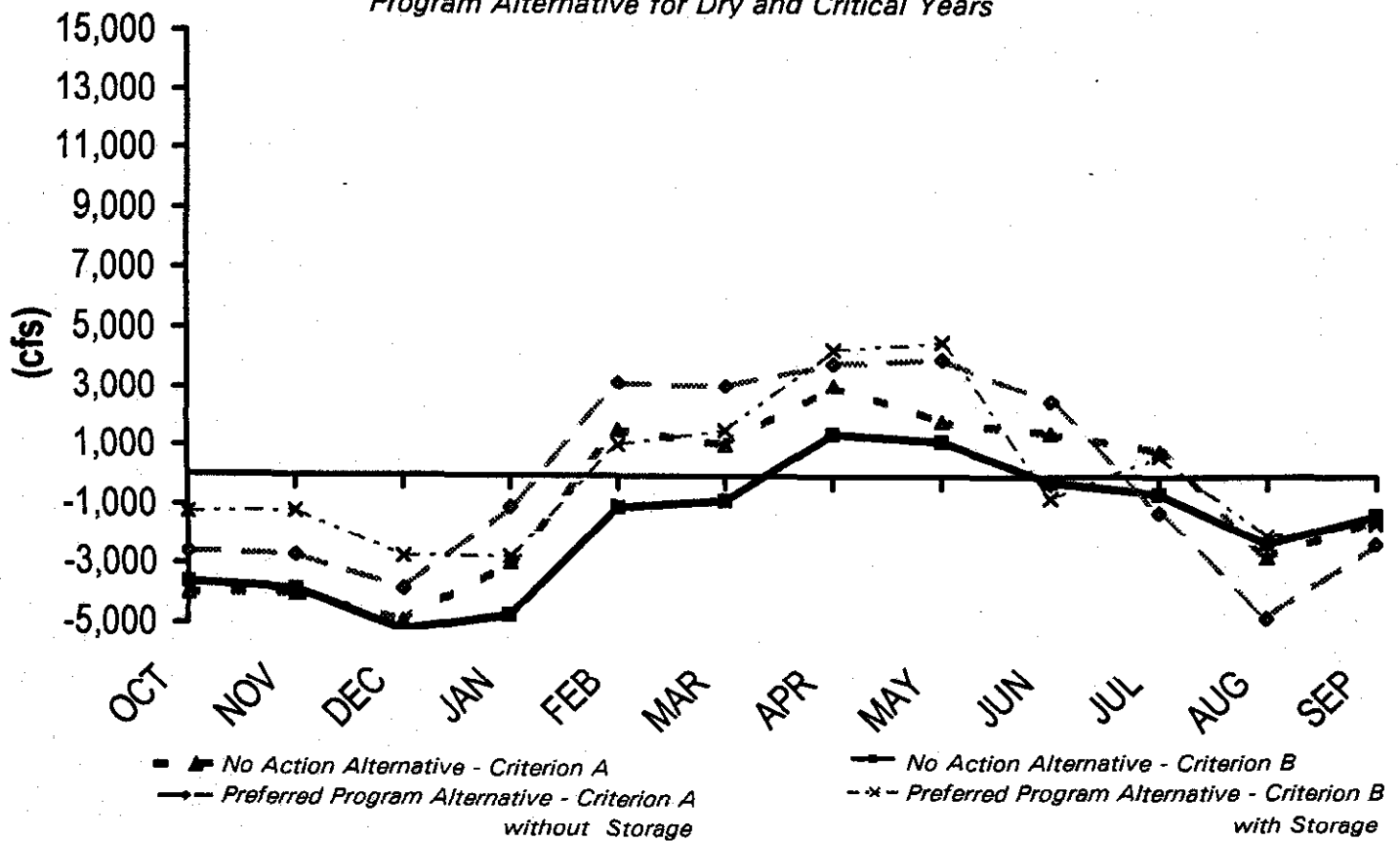


Figure 5.2-64. October QWEST Flows under All Program
Alternatives for the Long-Term Period

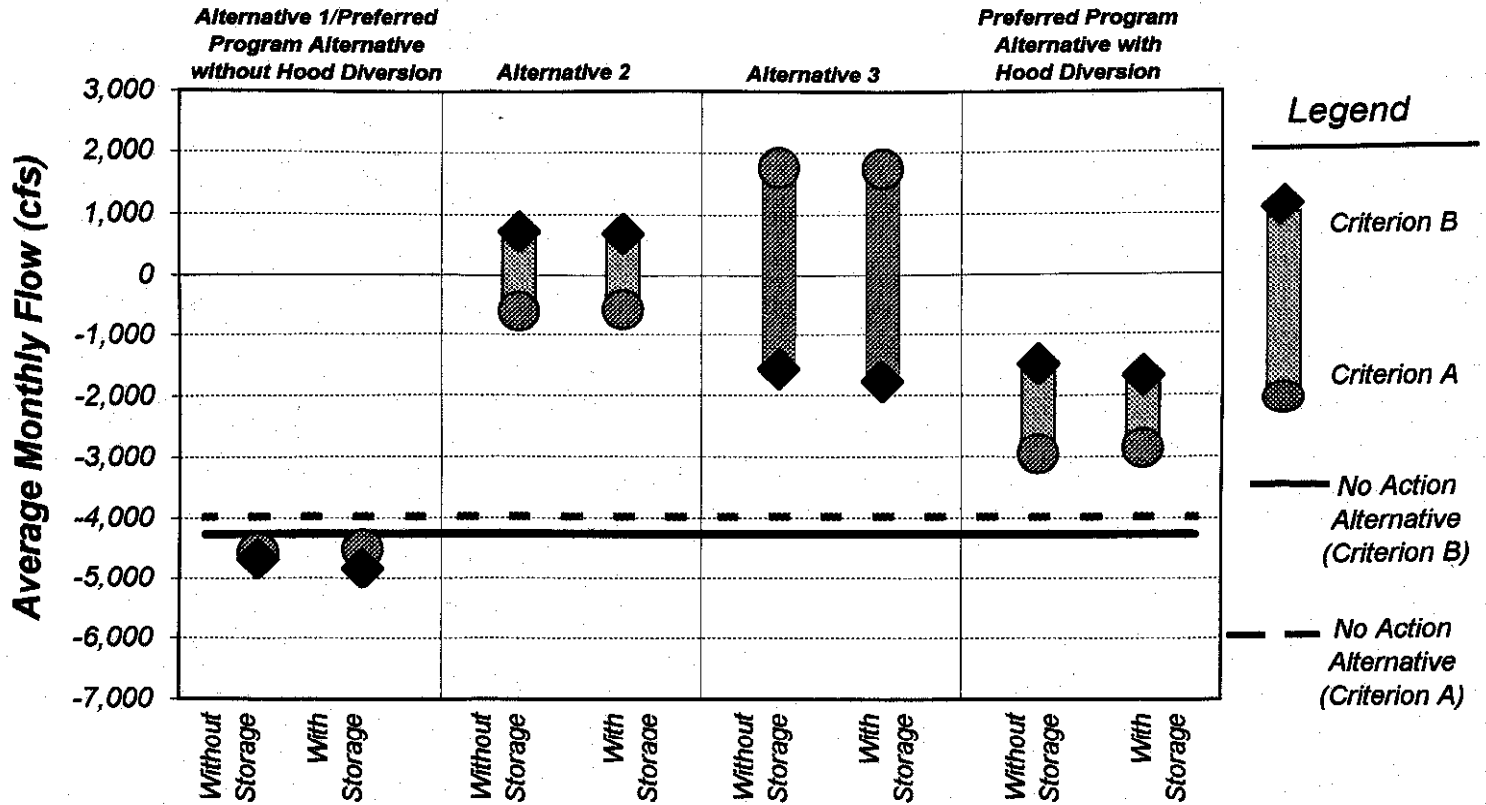
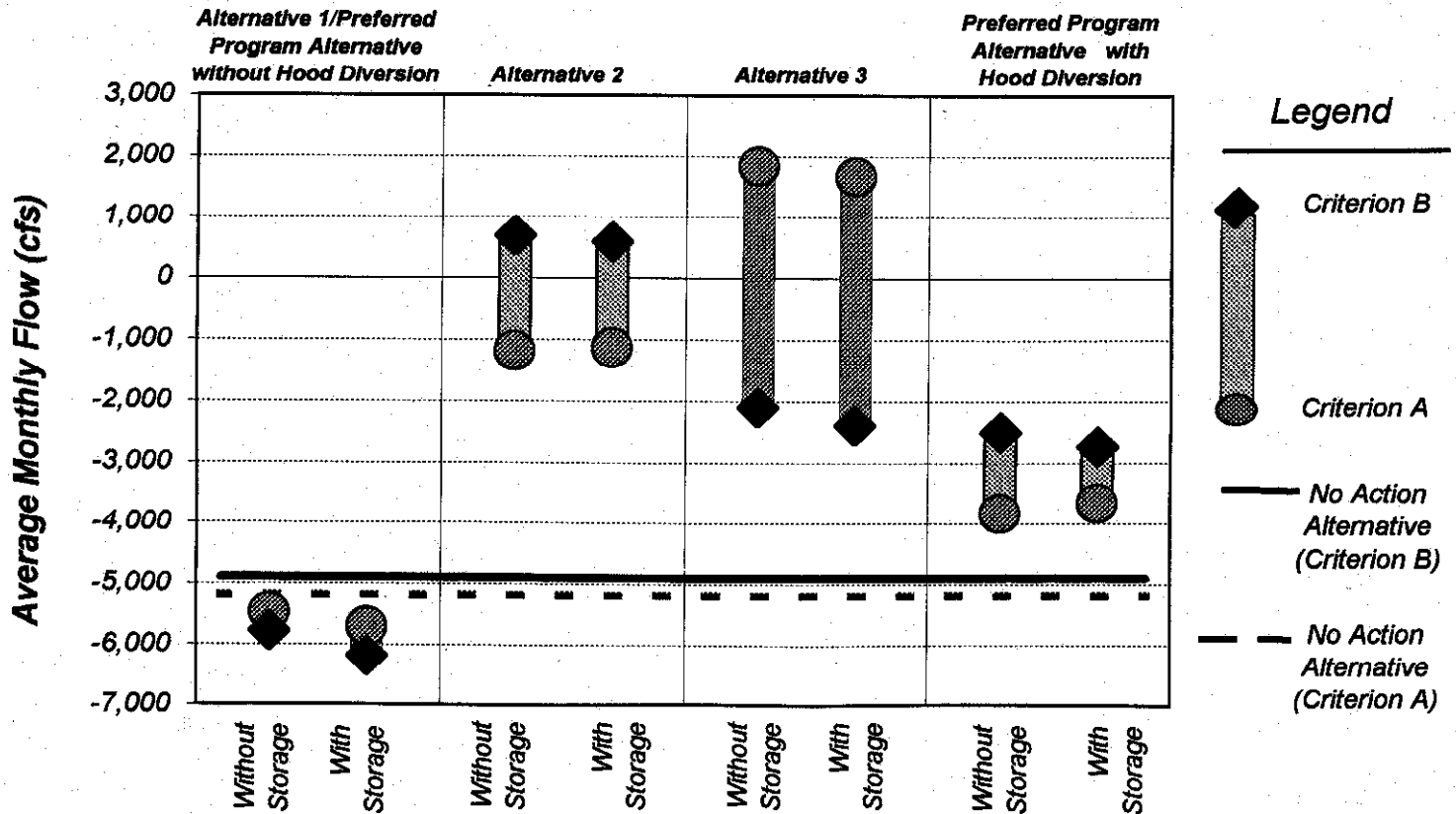


Figure 5.2-65. December QWEST Flows under All Program
Alternatives for Dry and Critical Years



cross-Delta flow in December and May typically increases. Over the long-term period under the Preferred Program Alternative, cross-Delta flow in August may vary by -2,500 cfs to 2,000 cfs relative to the No Action Alternative. Increases in cross-Delta flow over the long-term period ranges from 1,700 to 3,300 cfs in December and from 700 to 1,700 cfs in May. During dry and critical years under the Preferred Program Alternative, cross-Delta flow in August may vary by -2,000 to 1,600 cfs relative to the No Action Alternative. Increases in cross-Delta flow during dry and critical years range from 1,700 to 3,300 cfs in December and from 600 to 1,200 cfs in May. Figures 5.2-66 and 5.2-67 compare average monthly Cross-Delta flow for the long-term period and for dry and critical years, respectively.

Table 5.2-5. QWEST Flow under All Program Alternatives for the Long-Term Period (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak positive monthly flow (April)	6,400-9,100	5,800-9,100	8,900-10,300	6,100-11,200	8,300-10,000
Peak negative monthly flow (October)	(-4,000)-(-4,300)	(-4,800)-(-4,500)	(-600)-700	(-1,800)-1,800	(-3,000)-(-1,500)

Note:

PPA = Preferred Program Alternative.

Table 5.2-6. QWEST Flow under All Program Alternatives for the Dry and Critical Years (cfs)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Peak positive monthly flow (April)	1,400-3,100	1,400-3,100	3,100-4,400	1,500-5,000	3,100-4,300
Peak negative monthly flow (December)	(-4,900)-(-5,200)	(-6,200)-(-5,500)	(-1,200)-700	(-2,400)-1,800	(-3,800)-(-2,500)

Note:

PPA = Preferred Program Alternative.

Old River Flow at Bacon Island. Old River flow at Bacon Island was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in Old River at Bacon Island typically occurs in August and is about -3,400 cfs. In dry and critical years, the greatest reverse flow typically occurs in August and ranges from -3,000 to -3,600 cfs.

Over the long-term period under the Preferred Program Alternative, increases in reverse flow in Old River at Bacon Island in August range from 800 to 1,600 cfs, resulting in flow



Period 5.2-66. Monthly Average Cross-Delta Flow under the Preferred Program
Alternative for the Long-Term Period

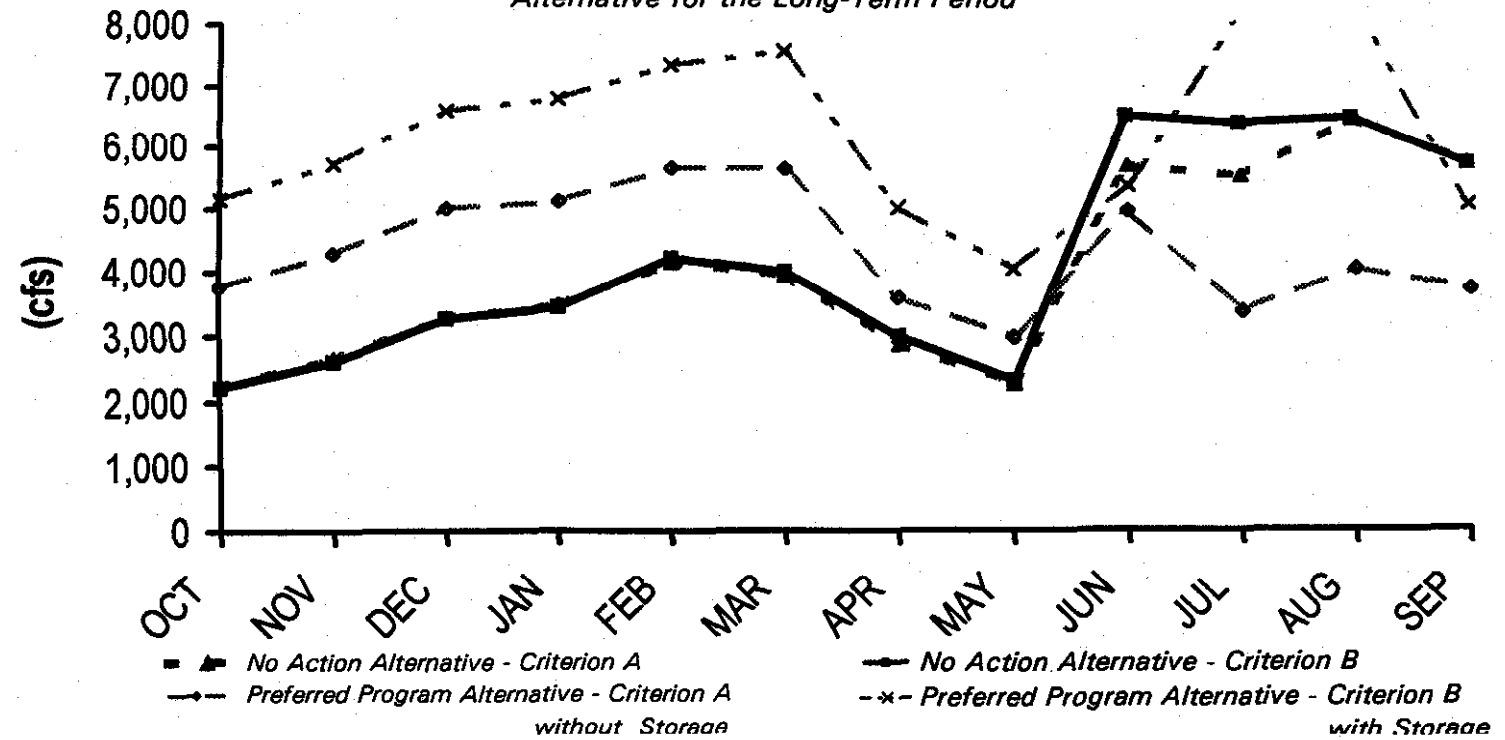


Figure 5.2-67. Monthly Average Cross-Delta Flow under the Preferred Program
Alternative for Dry and Critical Years

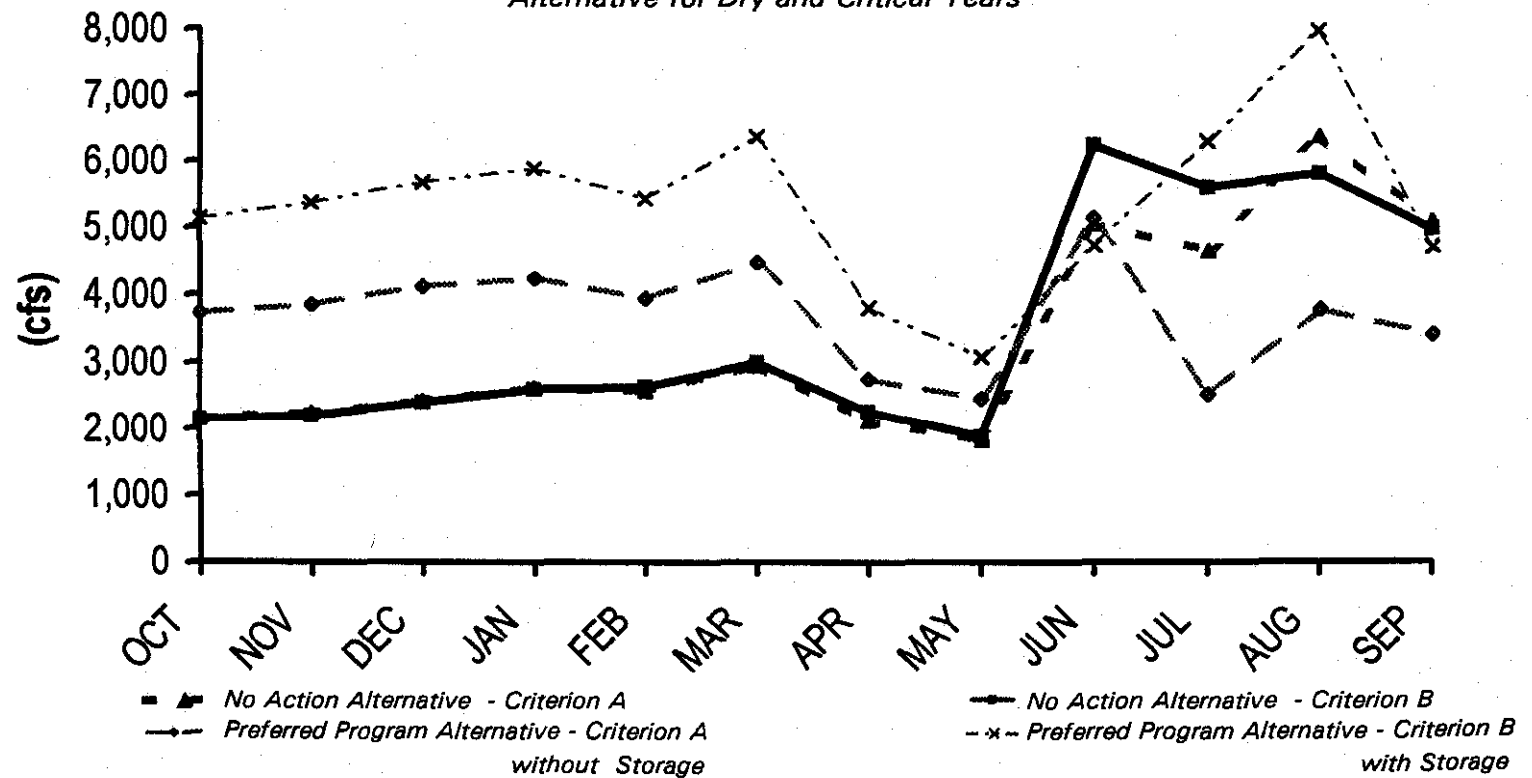


Figure 5.2-68. Monthly Average X2 Position under the Preferred Program Alternative for the Long-Term Period

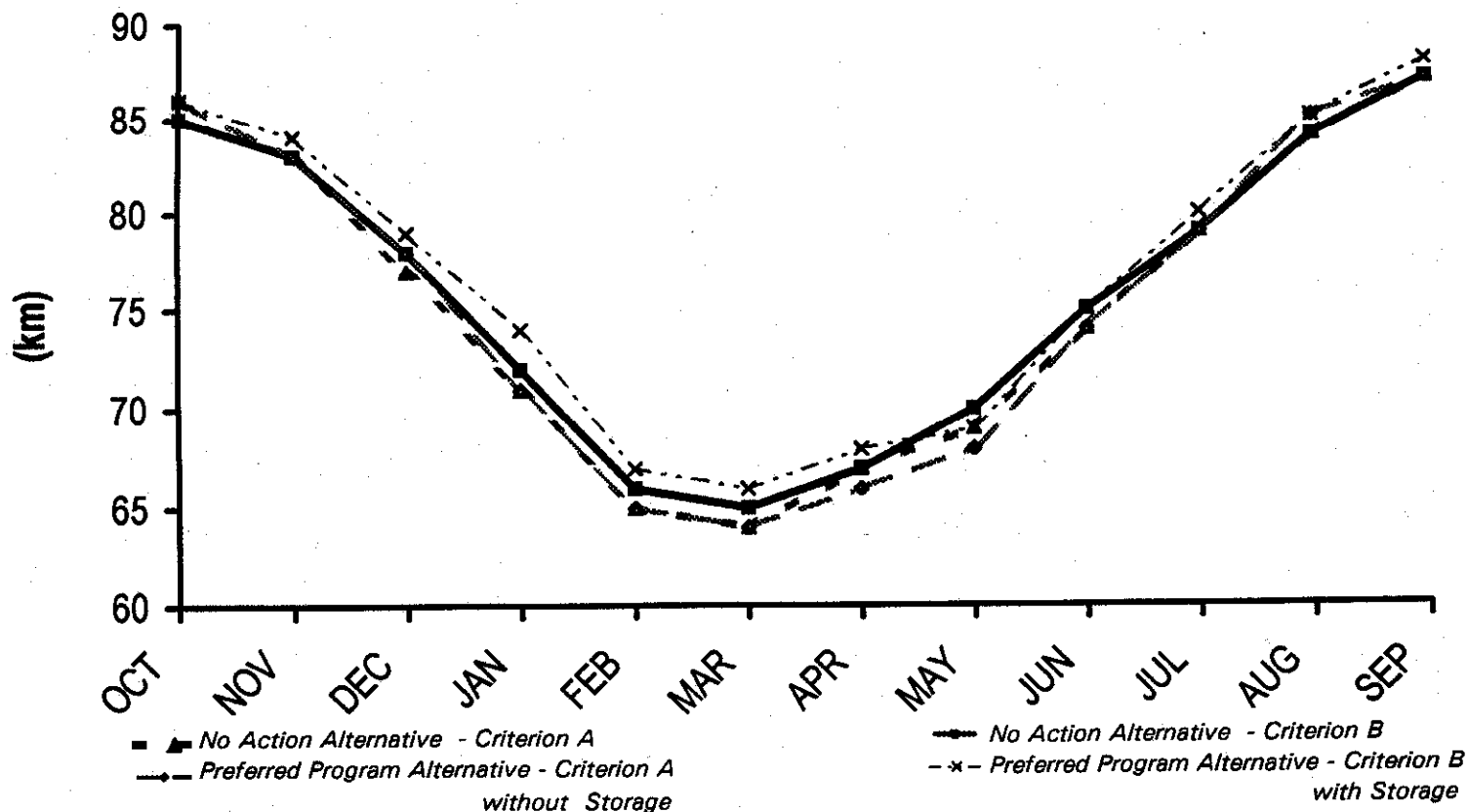


Figure 5.2-69. Monthly Average X2 Position under the Preferred Program Alternative for Dry and Critical Year

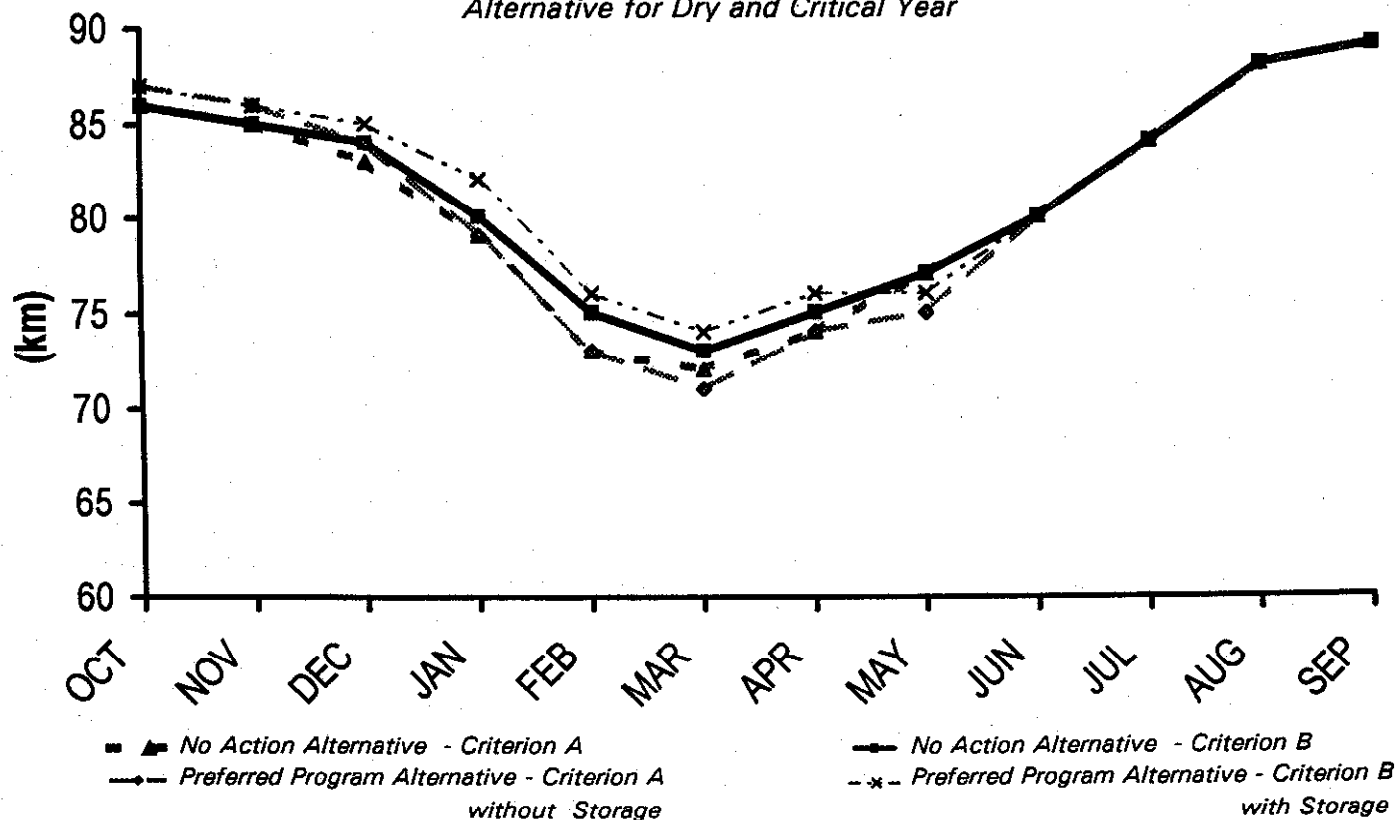


Figure 5.2-70. March X2 Position under All Program
Alternatives for the Long-Term Period

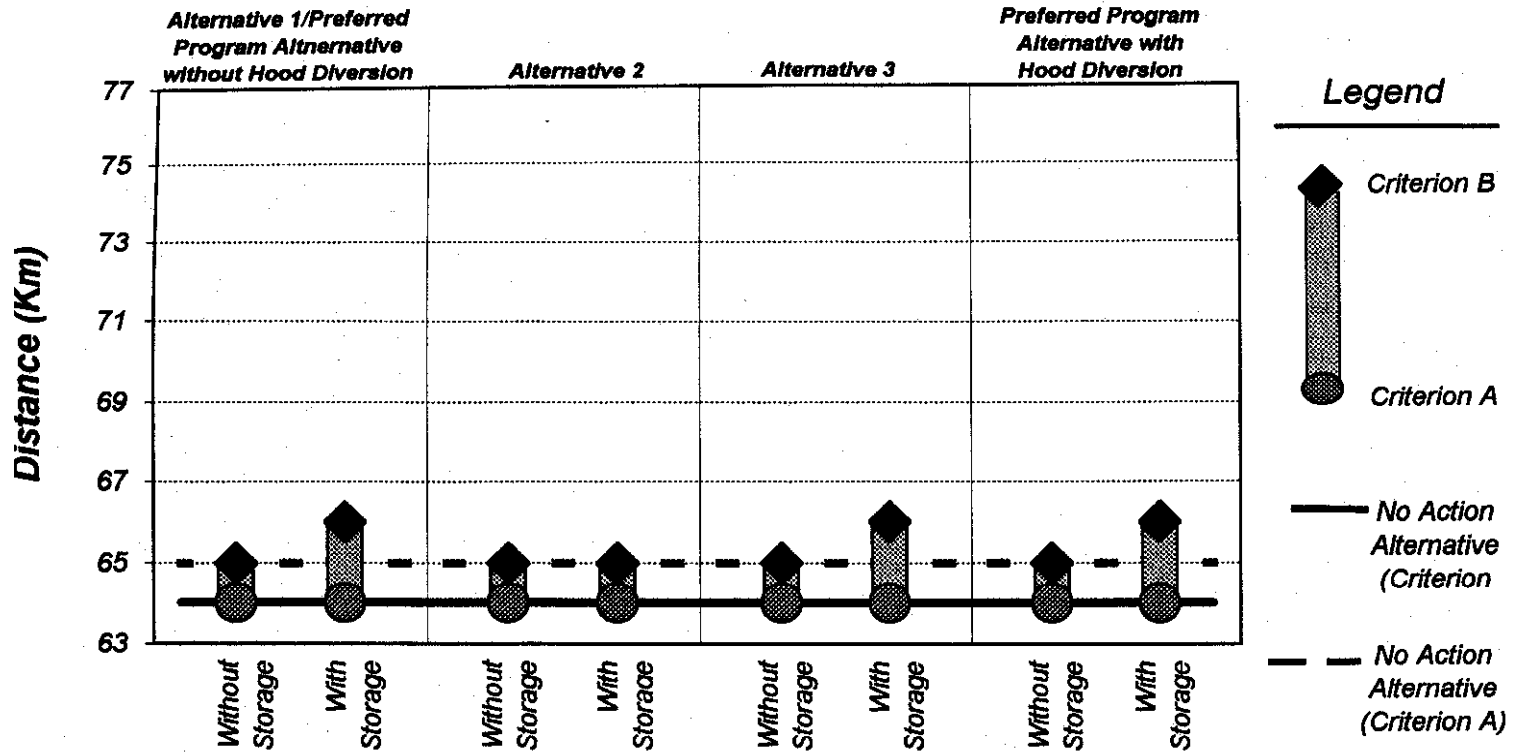
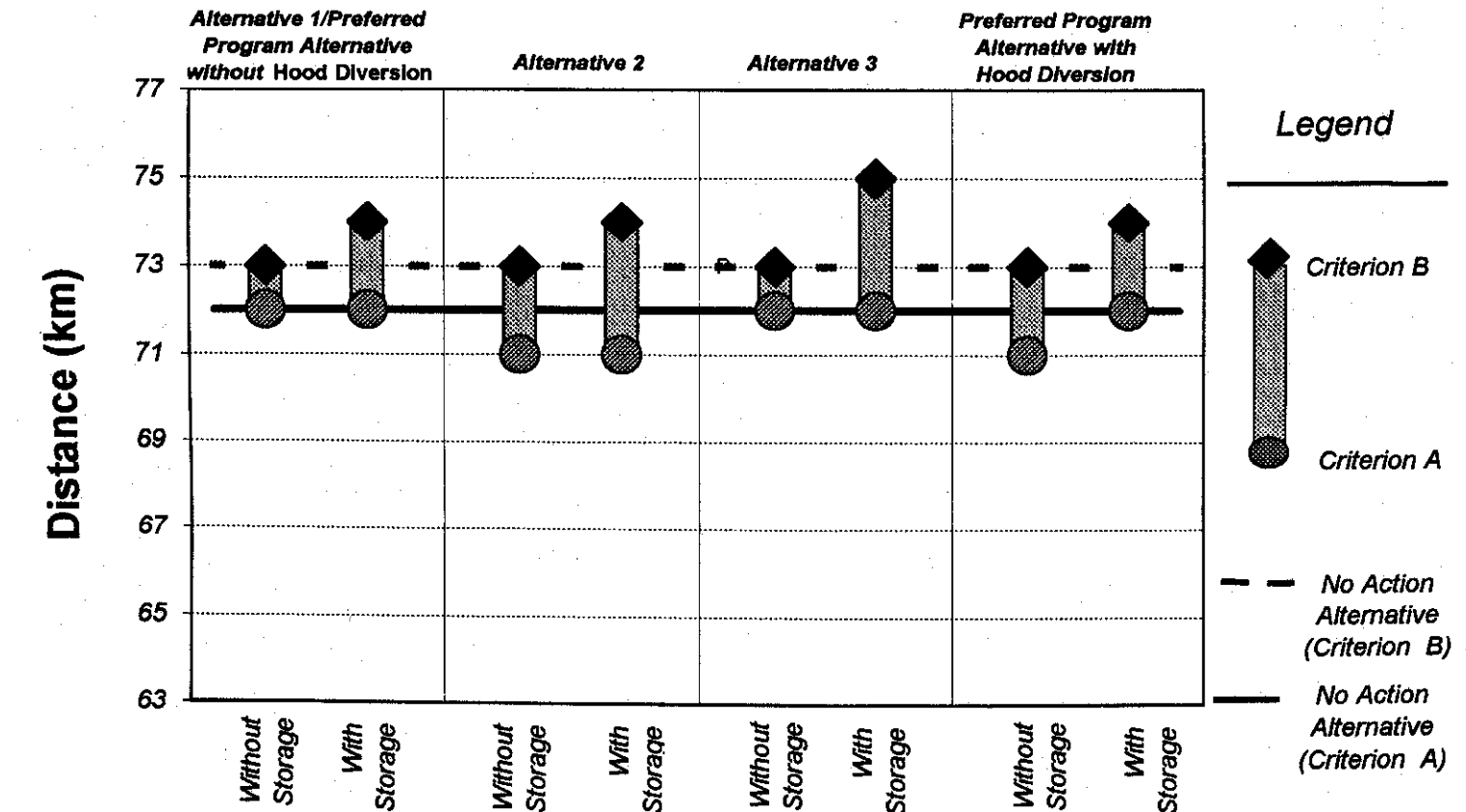


Figure 5.2-71. March X2 Position under All Program
Alternatives for Dry and Critical Years



ranging from -4,200 to -5,100 cfs. In dry and critical years under the Preferred Program Alternative, increases in reverse flow in August range from 100 to 900 cfs, resulting in flow ranging from -3,700 to -4,500 cfs.

San Joaquin River Flow at Antioch. San Joaquin River flow at Antioch was evaluated for the Preferred Program Alternative and the No Action Alternative for the long-term period and dry and critical years. Over the long-term period under the No Action Alternative, the greatest average monthly negative (reverse) flow in the San Joaquin River at Antioch typically occurs in October and ranges from -1,000 to -1,200 cfs. In dry and critical years, the greatest reverse flow typically occurs in December and ranges from -2,100 to -2,400 cfs.

Average monthly San Joaquin River flow at Antioch ranges from -900 to -2,900 cfs in August over the long-term period under the Preferred Program Alternative. In dry and critical years under Alternative 3, reverse flow in August may vary by -100 cfs to 1,700 cfs relative to the No Action Alternative, resulting in flow ranging from -700 to -2,500 cfs. Decreases in reverse flow in December range from 800 to 1,200 cfs under the Preferred Program Alternative in dry and critical years, resulting in flow ranging from -900 to -1,300 cfs.

Stage

Middle River Upstream of Victoria Island. The monthly average minimum stage in Middle River was evaluated for the No Action Alternative and the Preferred Program Alternative for the long-term period and dry and critical years. Flow control structures under the Preferred Program Alternative (same as described above for Alternative 1) are operated from April through October for all hydrologic periods. Over the long-term period under the No Action Alternative, the highest minimum stage in Middle River typically occurs in February and March and is about 0.1 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl.

In the absence of new surface storage, the Preferred Program Alternative increases water levels in Middle River by an average of 2.1 feet during the operation period, resulting in water surface elevations ranging from 1.3 to 2.0 feet above msl. Similar water levels result by implementing new surface storage under the Preferred Program Alternative during the period of operation. During dry and critical years under the No Action Alternative, the highest minimum stage in Middle River typically occurs in April and is about 0.5 foot below msl. The lowest minimum stage typically occurs in September and is about 0.7 foot below msl. The Preferred Program Alternative stage improvements for dry and critical years are similar to those described for the long-term period and resulting water levels range from 1.3 to 1.7 feet above msl.

Old River Flow at Bacon Island. The monthly average minimum stage in Old River was evaluated for the No Action Alternative and the Preferred Program Alternative for the long-term period and dry and critical years. Flow control structures under the Preferred Program Alternative are operated from April through October for all hydrologic periods. Over the long-term period under the No Action Alternative, the highest minimum stage



in Old River typically occurs in February and March and is about 0.6 foot above msl. The lowest minimum stage typically occurs in August and is about 0.7 foot below msl.

In the absence of new surface storage, the Preferred Program Alternative increases water levels in Old River by an average of 2.1 feet from June through September, resulting in water surface elevations ranging from 1.5 to 1.9 feet above msl. In November under the Preferred Program Alternative, monthly average minimum stage would decrease by up to 0.4 foot, resulting in water surface elevations as low as 0.8 foot below msl. During dry and critical years under the No Action Alternative, the highest minimum stage in Old River typically occurs in April and is about 0.3 foot below msl. The lowest minimum stage typically occurs in August and is about 0.8 foot below msl. The Preferred Program Alternative stage improvements for dry and critical years are similar to those described for the long-term period and resulting water levels range from 1.4 to 1.6 feet above msl. Water level decreases in November for dry and critical years are similar to those experienced for the long-term period and resulting water surface elevations are as low as 1.0 foot below msl.

Mass Fate

The DSM2 model was used to perform several mass tracking simulations for the Preferred Program Alternative. Discussion on this assessment method is provided in Section 5.2.4. Mass fate results are presented for existing conditions and all Program alternatives in Table 5.2-7 for high inflow and high export conditions. Similar results are presented in Table 5.2-8 for low inflow and high export conditions.

In the absence of new surface storage, the Preferred Program Alternative increases water levels by an average of 2.1 feet from June through September, resulting in water surface elevations ranging from 1.5 to 1.9 feet above msl. In November, monthly average minimum stage would decrease by up to 0.4 foot, resulting in water surface elevations as low as 0.8 foot below msl.

Table 5.2-7. Mass Tracking Results for High Inflow and High Export Conditions under All Program Alternatives (%)

ALTERNATIVE	CHIPPS ISLAND	EXPORTS	DELTA ISLANDS	IN-CHANNEL
Mass Injection at Freeport				
Existing conditions	96.5	1.7	0.6	1.2
No Action Alternative	95.0	3.0	0.6	1.4
Alternative 1	88.8	8.4	0.6	2.2
Alternative 2	85.0	13.3	0.8	0.9
Alternative 3	72.3	27.0	0.4	0.3
Preferred Program Alternative	86.5	11.0	0.8	1.7
Mass Injection at Prisoner's Point				
Existing conditions	77.8	15.8	1.3	5.1
No Action Alternative	65.8	26.8	1.1	6.3
Alternative 1	33.2	59.5	1.0	6.3
Alternative 2	55.7	42.3	0.8	1.2
Alternative 3	97.8	0.0	0.5	1.7
Preferred Program Alternative	45.3	50.7	1.0	3.0
Mass Injection at Vernalis				
Existing conditions	8.8	82.6	2.4	6.2
No Action Alternative	4.4	89.5	2.1	4.0
Alternative 1	0.7	96.2	1.9	1.2
Alternative 2	1.5	95.8	1.9	0.8
Alternative 3	38.3	39.8	3.0	18.9
Preferred Program Alternative	0.9	96.3	1.9	0.9



Figure 5.2-72. Average Monthly Sacramento River Flow at Freeport under the Preferred Program Alternative for the Long-Term Period

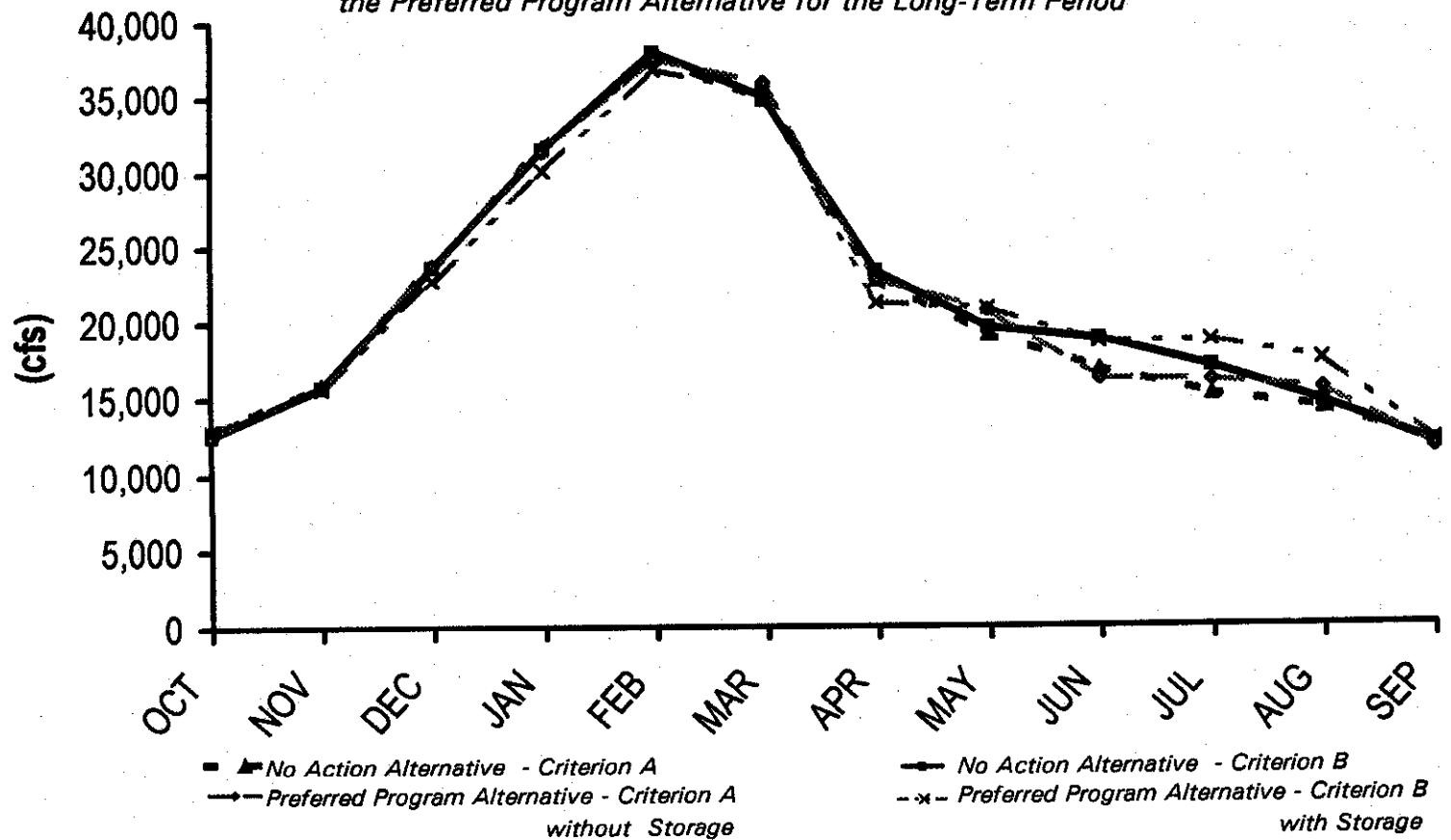
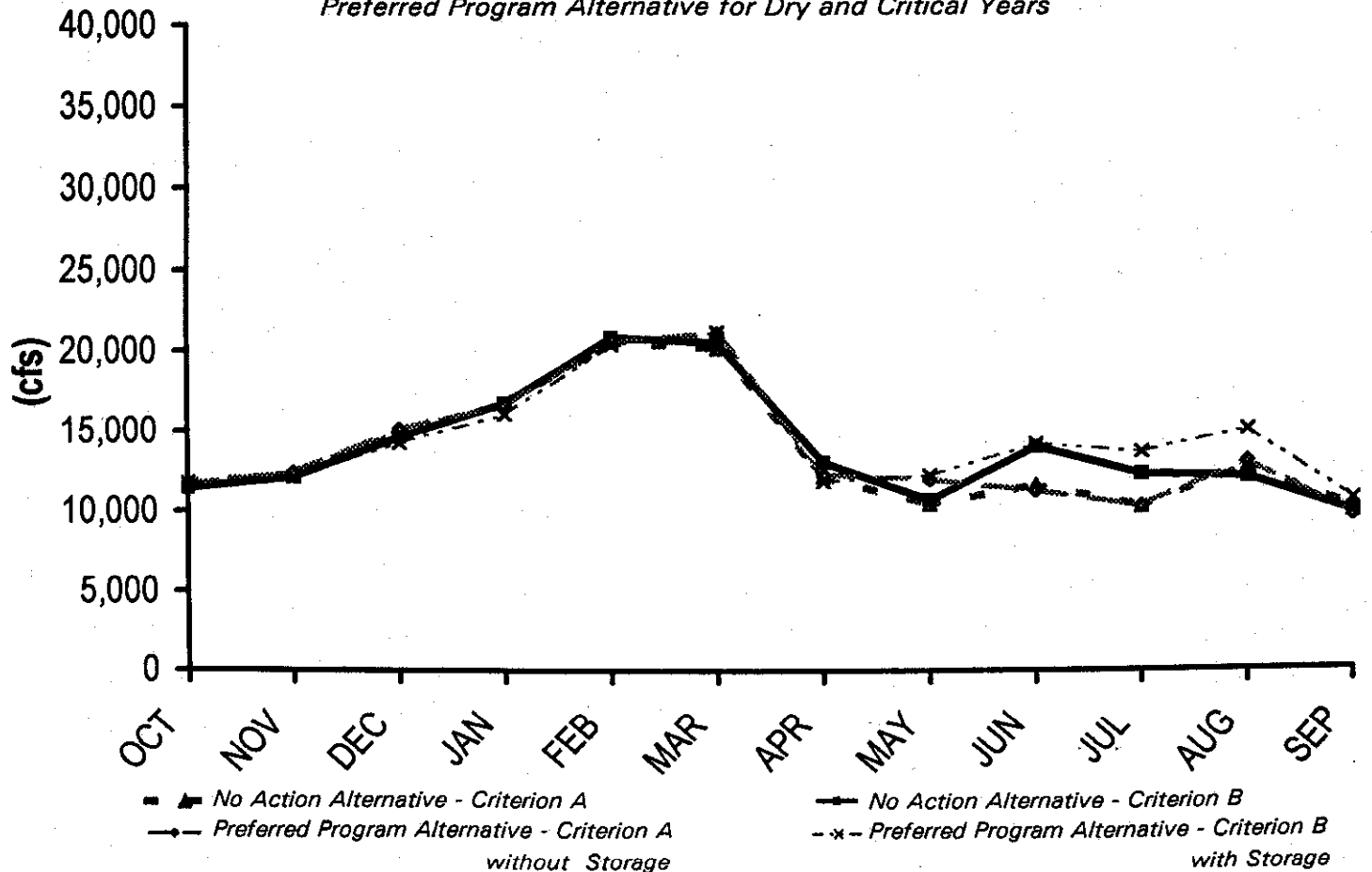


Figure 5.2-73. Average Monthly Sacramento River Flow at Freeport under the Preferred Program Alternative for Dry and Critical Years



*Table 5.2-8. Mass Tracking Results for Low Inflow and High Export
Conditions under All Program Alternatives (%)*

ALTERNATIVE	CHIPPS ISLAND	EXPORTS	DELTA ISLANDS	IN-CHANNEL
Mass Injection at Freeport				
Existing conditions	19.8	39.0	6.5	34.7
No Action Alternative	19.7	41.6	7.5	31.2
Alternative 1	19.1	40.3	7.6	33.0
Alternative 2	11.6	44.7	7.9	35.8
Alternative 3	16.5	47.6	4.2	31.7
Preferred Program Alternative	21.0	45.0	7.0	27.0
Mass Injection at Prisoner's Point				
Existing conditions	7.7	69.1	3.5	19.7
No Action Alternative	6.4	73.2	4.3	16.1
Alternative 1	7.2	70.3	4.3	18.2
Alternative 2	9.9	65.9	4.2	20.0
Alternative 3	16.5	6.9	5.4	71.2
Preferred Program Alternative	4.5	80.9	4.2	10.4
Mass Injection at Vernalis				
Existing conditions	0.0	92.4	6.0	1.6
No Action Alternative	0.0	91.4	7.6	1.0
Alternative 1	0.0	76.0	13.2	10.8
Alternative 2	0.0	76.3	13.2	10.5
Alternative 3	0.2	5.7	16.3	77.8
Preferred Program Alternative	0.0	81.6	12.9	5.5

Bay Region

The Preferred Program Alternative may increase the average monthly X2 position. Bay-Delta X2 position was evaluated for the No Action Alternative and the Preferred Program Alternative for the long-term period and for dry and critical years using DWRSIM modeling results. Over the long-term period under the No Action Alternative, the average monthly X2 position is typically farthest upstream in September and ranges from 86.9 to 87.0 km; average monthly X2 position is typically farthest downstream in March and ranges from 64.3 to 65.3 km.

The Preferred Program Alternative increases average monthly X2 position by about 0.6 km in September. The Preferred Program Alternative may increase or decrease average monthly X2 position by about 0.3 km in March. During dry and critical years under the No Action Alternative, average monthly X2 position is typically farthest upstream in September and ranges from 89.4 to 89.5 km; average monthly X2 is typically farthest downstream in March and ranges from 72.0 to 73.3 km. The Preferred Program Alternative decreases average monthly X2 position by about 0.1 km in September. The Preferred Program Alternative may decrease X2 position by about 0.5 km or increase X2 position by 0.3 km in March. Figures 5.2-68 and 5.2-69 compare average monthly X2 position for the long-term period and for dry and critical years, respectively.

The Preferred Program Alternative may increase the average monthly X2 position.



X2 position under the Preferred Program Alternative also was compared with X2 position under the other Program alternatives. The long-term period comparison is summarized in Table 5.2-9. The dry and critical year comparison is summarized in Table 5.2-10. Additionally, Figures 5.2-70 and 5.2-71 present X2 position comparisons for the long-term period and dry and critical years, respectively.

Table 5.2-9. X2 Position under All Program Alternatives for the Long-Term Period (km)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Upstream X2 position (September)	86.9-87.0	87.4-87.6	87.4-87.6	84.6-88.1	87.4-87.6
Downstream X2 position (March)	64.3-65.3	64.0-65.5	63.9-65.5	64.0-66.1	64.0-65.6

Note:
PPA = Preferred Program Alternative.

Table 5.2-10. X2 Position under All Program Alternatives for Dry and Critical Years (km)

PERIOD	NO ACTION	ALTERNATIVE 1/PPA (Without Hood)	ALTERNATIVE 2	ALTERNATIVE 3	PPA (With Hood)
Upstream X2 position (September)	89.4-89.5	89.4-89.5	89.3-89.5	85.5-89.5	89.3-89.5
Downstream X2 position (March)	72.0-73.3	71.6-73.6	71.4-73.7	71.6-74.5	71.5-73.6

Note:
PPA = Preferred Program Alternative.

Sacramento River and San Joaquin River Regions

Programmatic comparisons of river flows and existing storage releases in the Sacramento River and San Joaquin River Regions were made between the Preferred Program Alternative and the No Action Alternative using DWRSIM modeling results. Diversions and releases from new storage also were evaluated under the Preferred Program Alternative. For Sacramento River Region surface storage, river diversions under Criterion A are not allowed unless an instream daily flow of 20,000 cfs exists below the diversion location. No additional flow requirements are specified as constraints to diversions under Criterion B in the modeling analysis.

Average monthly flow in the Sacramento River at Freeport was evaluated for the Preferred Program Alternative and the No Action Alternative. Figures 5.2-72 and 5.2-73 compare average monthly Sacramento River flow at Freeport for the long-term period and for dry and critical years, respectively.

The Preferred Program Alternative has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative.



Figure 5.2-74. Average Monthly San Joaquin River Flow at Vernalis under the Preferred Program Alternative for the Long-Term Period

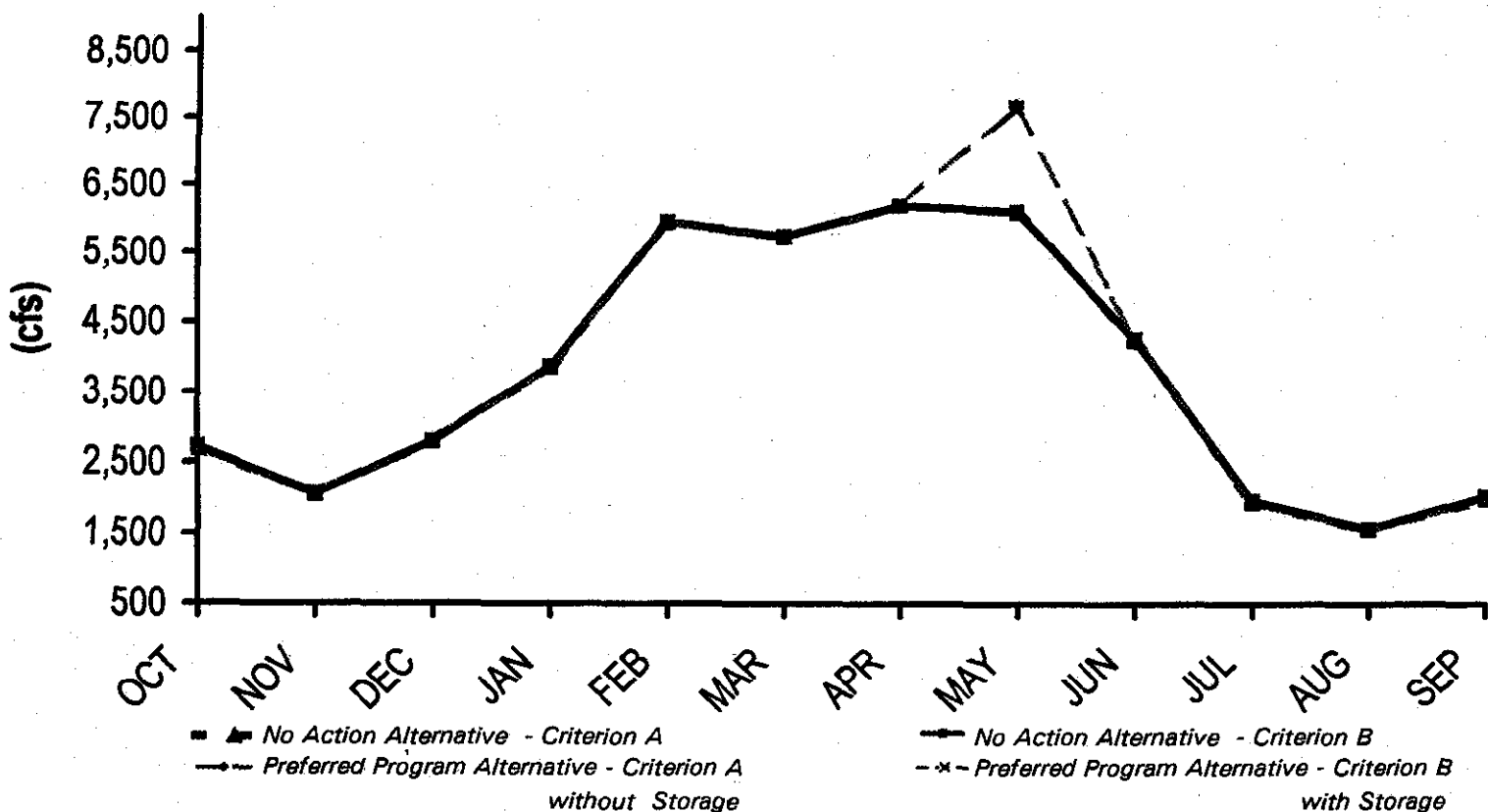


Figure 5.2-75. Average Monthly San Joaquin River Flow at Vernalis under the Preferred Program Alternative for Dry and Critical Years

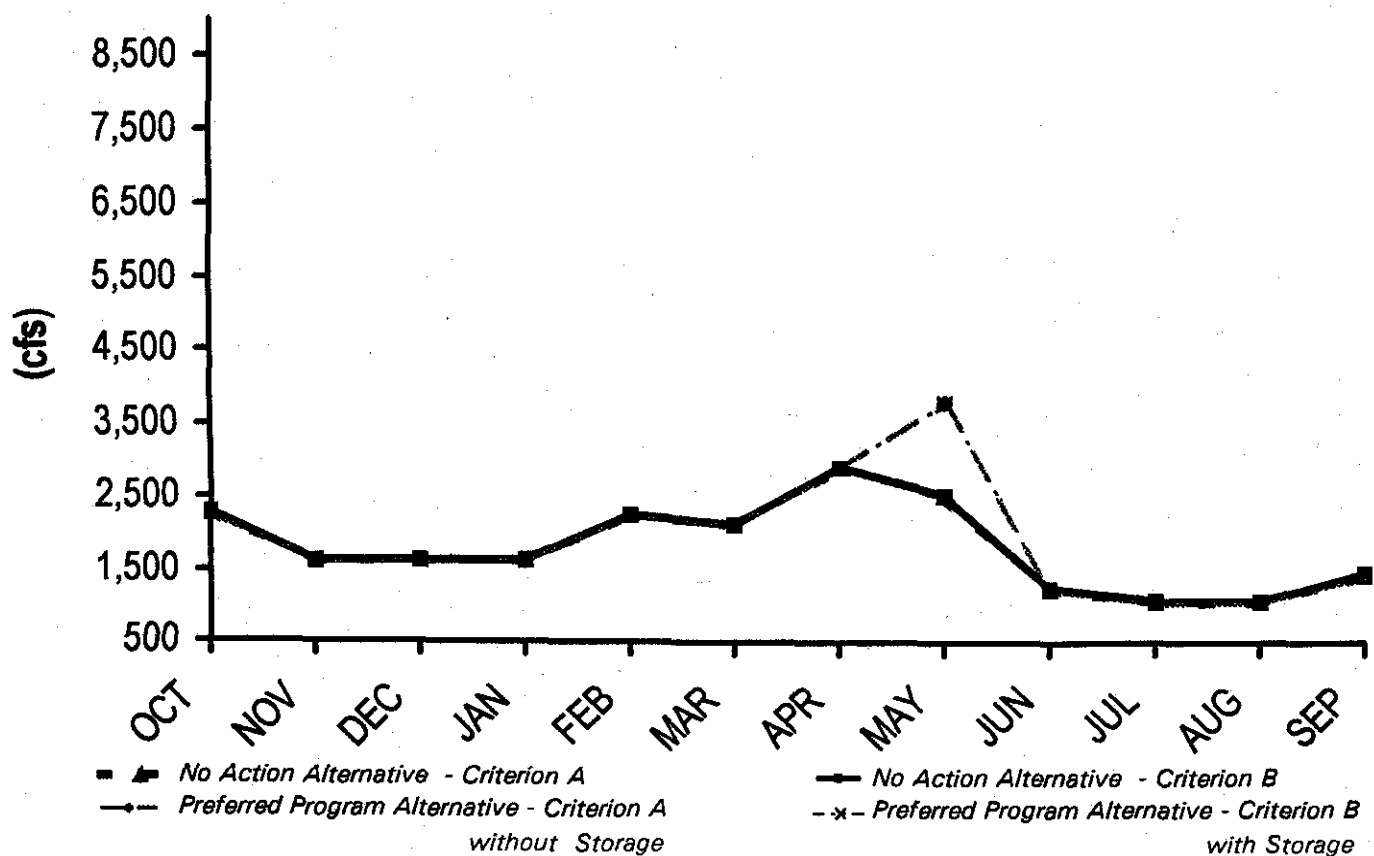


Figure 5.2-76. New Surface Storage Diversions in the Sacramento River Region under the Preferred Program Alternative for the Long-Term Period

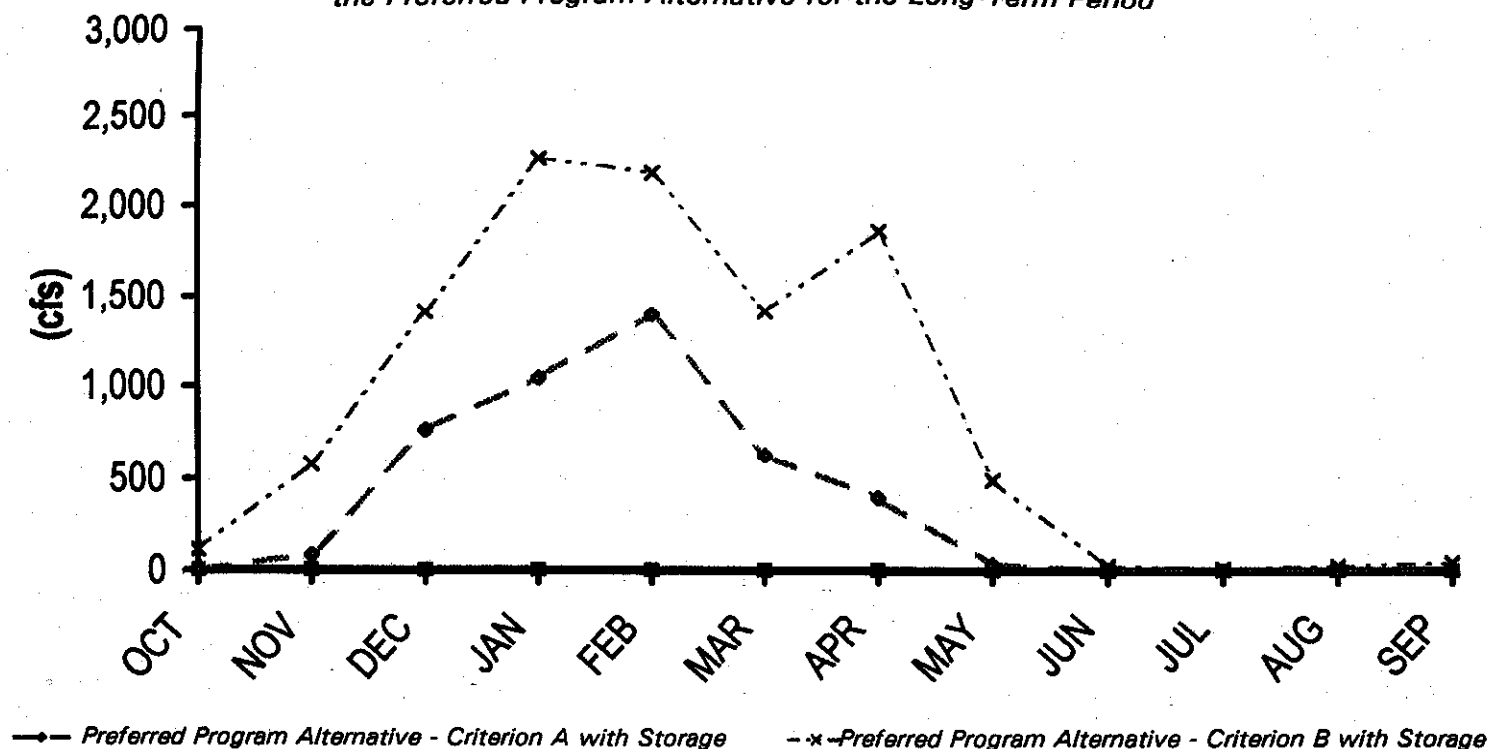
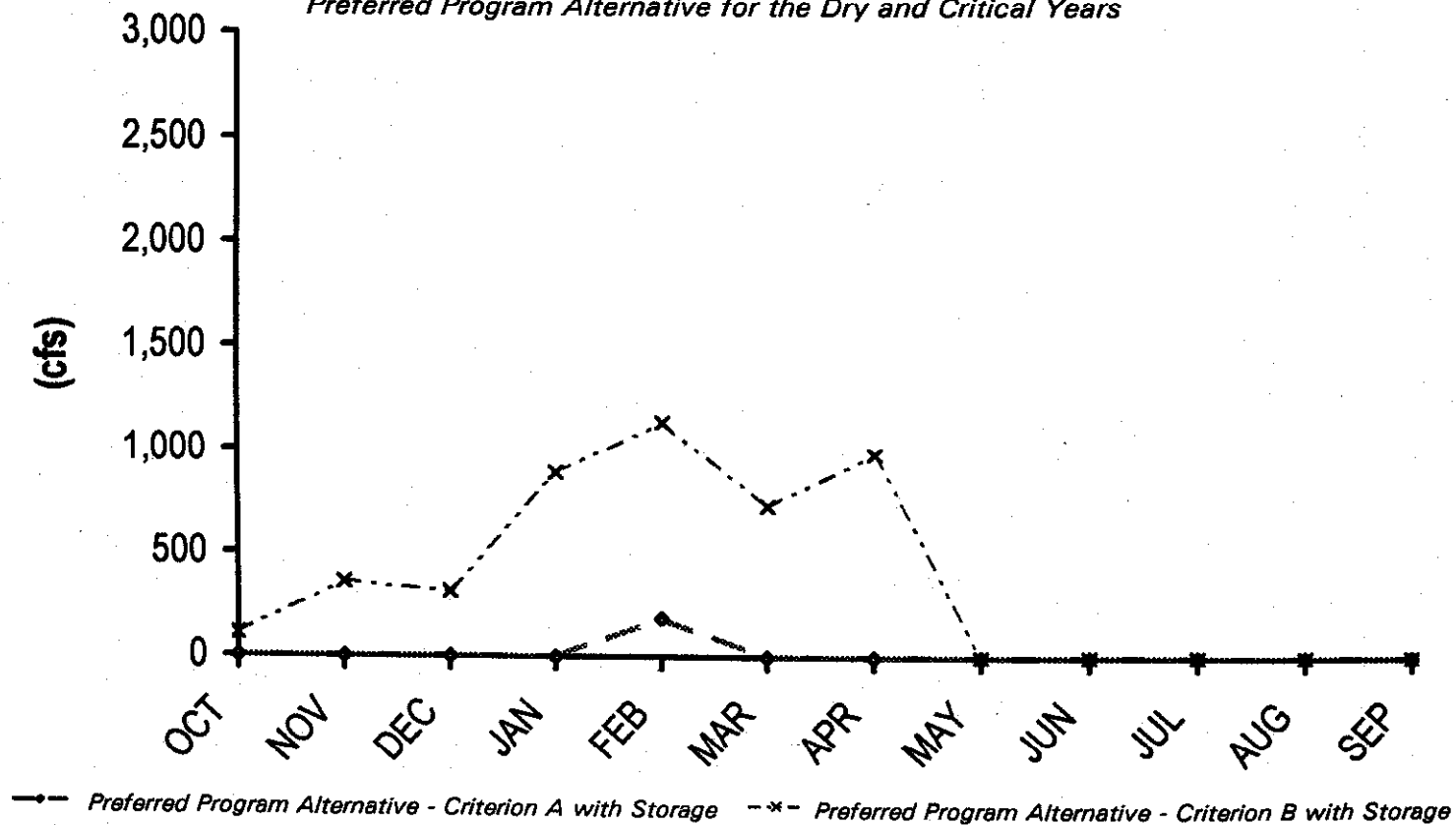


Figure 5.2-77. New Surface Diversions in the Sacramento River Region under the Preferred Program Alternative for the Dry and Critical Years



In the absence of new storage facilities, the Preferred Program Alternative has little impact on average monthly flow in the Sacramento River at Freeport relative to the No Action Alternative. The greatest differences occur in summer months under all hydrologic conditions. The Preferred Program Alternative increases average monthly flow by as much as 1,700 cfs during summer. Even with new storage facilities, the Preferred Program Alternative has little impact on average monthly flow in most months. Anticipated flow increases are most pronounced during summer months of dry and critical years—up to 1,400 cfs.

Average monthly flow in the San Joaquin River at Vernalis was evaluated for the Preferred Program Alternative and the No Action Alternative. Figures 5.2-74 and 5.2-75 compare average monthly San Joaquin River flow at Vernalis for the long-term period and for dry and critical years, respectively.

Under the Preferred Program Alternative, San Joaquin River flow is unchanged throughout the year relative to the No Action Alternative except for early spring. The Preferred Program Alternative increases average monthly flow in spring by as much as 1,600 cfs over the long-term period. This range is not influenced by storage or water management assumptions. The same trends occur during the long-term period and dry and critical years, with an increase of 1,300 cfs in monthly average flow for dry and critical years.

Existing Reservoir Releases. Existing Sacramento River Region reservoir releases generally peak in summer months under the No Action Alternative as well as under the Preferred Program Alternative. This pattern is consistent for the long-term period and dry and critical years. Average monthly summer releases under the No Action Alternative range from 21,700 to 22,600 cfs.

Under the Preferred Program Alternative, the lowest long-term period summer releases are generally associated with the Criterion B water management assumptions in conjunction with new storage facilities. The greatest long-term period summer releases are associated with the Criterion B water management assumptions in the absence of additional storage capacity. New storage would provide increased operational flexibility and would supplement releases from existing facilities.

If no new storage is implemented under the Preferred Program Alternative, summer releases from existing facilities may increase up to 1,300 cfs relative to the No Action Alternative. If new storage is implemented under the Preferred Program Alternative, releases may decrease as much as 1,000 cfs or increase up to 300 cfs relative to the No Action Alternative. During winter months, new storage tends to increase releases from existing facilities. Higher annual storage carryover in existing facilities, which is associated with implementation of new storage in the Preferred Program Alternative, necessitates increased flood control releases in winter months.

Average monthly San Joaquin River Region reservoir releases are unchanged from the No Action Alternative by implementation of the Preferred Program Alternative. Release patterns are not influenced by varying water management strategies or by implementation of new surface storage.

Existing Sacramento River Region reservoir releases generally peak in summer months under the No Action Alternative as well as under the Preferred Program Alternative.

If no new storage is implemented under the Preferred Program Alternative, summer releases from existing facilities may increase up to 1,300 cfs relative to the No Action Alternative. If new storage is implemented under the Preferred Program Alternative, releases may decrease as much as 1,000 cfs or increase up to 300 cfs relative to the No Action Alternative.



New Reservoir Diversions and Releases. Figures 5.2-76 and 5.2-77 present the ranges of long-term period and dry and critical year diversions into new Sacramento River Region storage under the Preferred Program Alternative. New surface storage diversions typically occur during winter and spring months, with peak diversions in late winter. For the Preferred Program Alternative, over the long-term period, the range of peak average monthly diversions is from 1,400 to 2,200 cfs. For dry and critical years, the range of peak average monthly diversions is from 200 to 1,100 cfs.

Environmental releases from new Sacramento River Region reservoir storage occur during spring and summer months when the greatest environmental benefits are anticipated, with peak releases occurring in late spring and early summer. Release patterns over the long-term period are similar to those for dry and critical years. Environmental releases from new storage are largely unaffected by the range of Delta water management criteria, although a small increase in spring releases may be realized under Criterion B. Maximum average monthly releases in dry and critical years are on the order of 1,200 cfs, while maximum average monthly releases are approximately 900 cfs for the long-term period.

Peak average monthly water supply releases from new Sacramento River Region reservoir storage generally occur in midsummer to meet Delta export demands. Peak average monthly releases in the Sacramento River Region range from 1,600 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions. For dry and critical years, peak releases range from 1,200 to over 2,200 cfs.

New San Joaquin River Region surface storage diversions typically occur from fall through spring. Diversions continue as late as midsummer, since snow melt constitutes a significant portion of runoff. Maximum diversions during dry and critical years occur in early summer (140 cfs), while average monthly diversions over the long-term period are greatest in late winter (160 cfs).

Releases from new surface storage in the San Joaquin River Region occur primarily in spring. No variation in releases is evident between the water management scenarios under the Preferred Program Alternative. Maximum average monthly releases range from 550 to 560 cfs for the long-term period and 340 to 350 cfs for dry and critical years.

5.2.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

This section presents a comparison of existing conditions to the Program alternatives for determining environmental consequences. As discussed earlier, potential changes to Bay-Delta hydrodynamics and riverine hydraulics due to Program actions are discussed in this section; the environmental implications of these changes are addressed in other sections of this report in the context of the resources affected by the changes. The programmatic analysis found that the effects on Bay-Delta hydrodynamics and riverine hydraulics from

Over the long-term period, the range of peak average monthly diversions is from 1,400 to 2,200 cfs. For dry and critical years, the range of peak average monthly diversions is from 200 to 1,100 cfs.

Peak average monthly releases in the Sacramento River Region range from 1,600 to 2,800 cfs for the long-term period, with the upper end reflecting Criterion B assumptions.

No variation in releases is evident between the water management scenarios under the Preferred Program Alternative for the San Joaquin River Region.



implementing any of the Program alternatives when compared to existing conditions are within the same range of effects as those identified in Sections 5.2.7 and 5.2.8.

As discussed in Section 5.1.4, in order to make programmatic comparisons between the No Action Alternative and Program alternatives, existing conditions were simulated based on an extensive set of modeling assumptions. The No Action Alternative was defined to represent a reasonable range of uncertainty in the preimplementation condition. This range of uncertainty was quantified for purposes of this programmatic document by formulating two distinct bookend water management criteria assumptions sets. These two sets of assumptions (Criteria A and B) serve as boundaries for a range of possible Delta inflow, export, and outflow patterns in the No Action Alternative programmatic analysis. The primary assumptions that differentiate the No Action Alternative bookends from each other (and from existing conditions) are Bay-Delta system water demands and various Delta management criteria that regulate system operations.

Under Criterion A, the Program assumes that 1995-level Bay-Delta system water demands (the same demands used to define existing conditions) apply throughout the Program planning horizon. Under this assumption, any future increase in demands in the Program study area would be met by alternative supply or demand management options. This bookend of the No Action Alternative also includes more protective Delta management criteria regulating flows and exports. While specific assumptions regarding Delta management criteria were made to complete the water simulation modeling, the Program's intention is to depict a general level of protection. These assumptions should not be interpreted as specific predictions of future Delta management requirements. Criterion A results in generally lower Delta exports than existing conditions.

Under Criterion B, the Program assumes Bay-Delta system water demands increase by about 10%. This bookend of the No Action Alternative includes no change in Delta management criteria from existing conditions. Criterion B results in generally higher Delta exports than existing conditions.

A comparison of effects on Bay-Delta hydrodynamics and riverine hydraulics of the Program alternatives relative to existing conditions indicates that:

- All potentially significant effects that were identified when compared to the No Action Alternative would still be considered significant when compared to existing conditions.
- No additional potentially significant effects are identified when Program alternatives are compared to existing conditions as opposed to the No Action Alternative.

Under Criterion A, the Program assumes that 1995-level Bay-Delta system water demands (the same demands used to define existing conditions) apply throughout the Program planning horizon. Criterion A results in generally lower Delta exports than existing conditions.

Under Criterion B, the Program assumes Bay-Delta system water demands increase by about 10%. Criterion B results in generally higher Delta exports than existing conditions.



5.2.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. The incremental effects of the Preferred Program Alternative, when added to other past, present, and reasonably foreseeable future actions, could result in cumulative effects on Bay-Delta hydrodynamics and riverine hydraulics. These cumulative effects are discussed in this section; the resulting environmental implications are addressed in other sections of this report in the context of the affected resources. Refer to Chapter 3 for a summary of cumulative impacts for all resource categories. Refer to Attachment A for a list and descriptions of the projects and programs considered in this programmatic evaluation.

Projects and actions that are included in the analysis of existing conditions and the No Action Alternative were described earlier, along with the discussion of impacts of the No Action Alternative compared to existing conditions. Related past, present, and probable future projects and actions have been evaluated for their potential to contribute to cumulative effects.

The following projects would result in negligible effects on Bay-Delta hydrodynamics and riverine hydraulics: CCWD Multi-Purpose Pipeline Project, Hamilton City Pumping Plant Fish Screen Improvement Project, Montezuma Wetlands Project, Sacramento River Flood Control System Evaluation, West Delta Watershed Program, and the Sacramento River Conservation Area Program. The effects on Bay-Delta hydrodynamics and riverine hydraulics of the Trinity River Restoration Project, ISDP, and urbanization were evaluated in Sections 5.1.7 and 5.1.8. Consequently, these projects would not contribute to additional cumulative effects on Bay-Delta hydrodynamics and riverine hydraulics.

The effects on Bay-Delta hydrodynamics and riverine hydraulics of the Trinity River Restoration Project, ISDP, and urbanization were evaluated in Sections 5.1.7 and 5.1.8.

The following projects could lead to or involve increased storage and diversion of water for consumptive use: American River Watershed Project, American River Water Resource Investigation, CVPIA Anadromous Fish Restoration Program and other CVPIA actions not yet fully implemented, Delta Wetlands Project, Pardee Reservoir Enlargement Project, Red Bluff Diversion Dam Fish Passage Program, Sacramento Water Forum process, Supplemental Water Supply Project, Sacramento County municipal and industrial water supply contracts, and Program actions. Together, these projects could affect river flows or Delta water circulation and cause cumulative effects on Bay-Delta hydrodynamics and riverine hydraulics.

Mitigation strategies have been identified that would reduce the environmental impacts for Program actions and for projects included in Attachment A. These mitigation strategies would include project operation and coordination to minimize adverse effects on Bay-Delta hydrodynamics and riverine hydraulics. Potential impacts due to changes in Bay-Delta hydrodynamics and riverine hydraulics will be addressed during project authorization or establishment of water rights.

Growth-Inducing Impacts. Changes in Bay-Delta hydrodynamics and riverine hydraulics caused by the Preferred Program Alternative are not expected to result in growth-inducing impacts.



Short- and Long-Term Relationships. Short-term, construction-related effects on Bay-Delta hydrodynamics and riverine hydraulics would be localized and cease after construction is completed. Where possible, avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts on affected resources.

Irreversible and Irretrievable Commitments. The Water Use Efficiency, Water Transfer, Water Quality, Storage, Conveyance, and other elements of the Preferred Program Alternative can be considered to cause significant irreversible changes to Bay-Delta hydrodynamics and riverine hydraulics. The environmental consequences of these irreversible changes, along with possible avoidance and mitigation measures, are addressed in other sections of this report in the context of the affected resources.

5.2.11 MITIGATION STRATEGIES

As described in Section 5.2.5, while Program-induced changes in Bay-Delta hydrodynamics and riverine hydraulics are described in this section, the significance and environmental impacts of these changes are addressed in other sections of this report in the context of each of the resources affected by the changes. Mitigation strategies to deal with potential effects also are discussed in the sections of this report in the context of the affected resources.

5.2.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Any potentially significant unavoidable impacts on resources affected by Program-induced changes in Bay-Delta hydrodynamics and riverine hydraulics are described in other sections of this report in the context of each of the resources affected by the changes.

Any potentially significant unavoidable impacts on resources affected by Program-induced changes in Bay-Delta hydrodynamics and riverine hydraulics are described in other sections of this report in the context of each of the resources affected by the changes.

